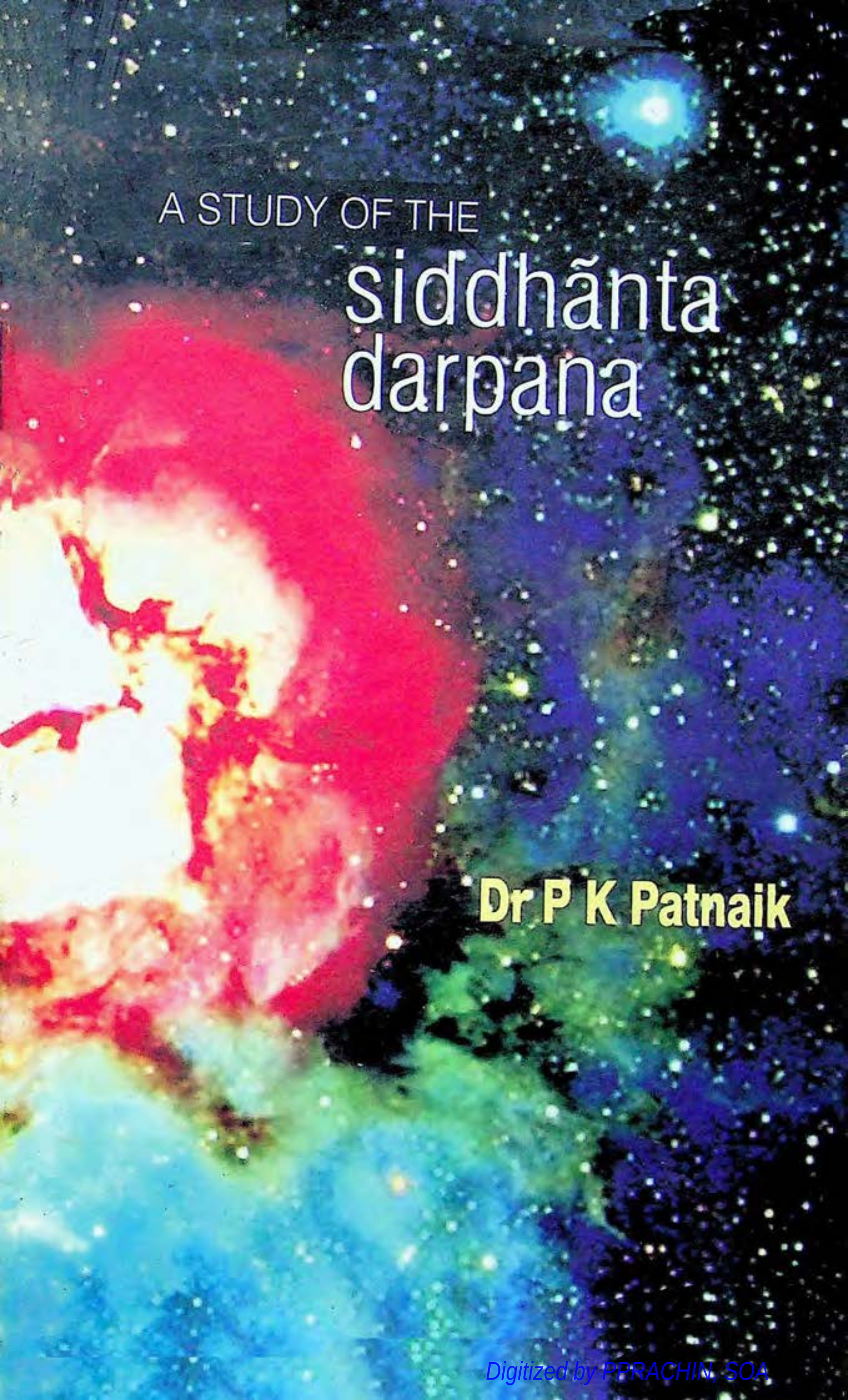

A STUDY OF THE

siddhãnta darpana

Dr P K Patnaik

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A STUDY OF THE SIDDHÃNTA DARPANA

Dr P K Patnaik

MINERVA PRESS
NEW DELHI
LONDON MUMBAI

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ISBN 81 7662 329 6

First Published 2005 by
MINERVA PRESS
5-E, First Floor
Rani Jhansi Road
Jhandewalan Extn
New Delhi – 110 055

Printed & bound in India
for Minerva Press (India) Pvt. Ltd.

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TESTIMONY

This is to certify that the thesis entitled *A Study of the Siddhānta Darpana* being submitted by Dr P K Patnaik, Reader in Oriya, SCS (Autonomous) College, Puri, for the award of the degree of DLitt in Sanskrit of Berhampur University, registered vide no. 34/96 (w.e.f. 19 May 1994) is a record of bonafide research work independently carried out by him under the scheme of Minor Research Project of the UGC vide letter of approval no. PHO 84/98– 99 ERO of 25 February 1999.

Dr Patnaik is a fit and proper person in character and habit for the Doctor's degree.

Principal
SCS (Autonomous) College, Puri

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SUBMISSION

I herewith submit the thesis entitled *A Study of the Siddhānta Darpana* for award of the degree of D Litt in Sanskrit of Berhampur University, registered vide no. 34/96 with effect from 19 May 1994. It is a record of bonafide research work independently carried out by me fulfilling the conditions as laid down in this behalf in the statutes and regulations (amended up to 31 August 1988). I certify that this thesis has not at any time been previously submitted in this university or in any other university for the doctor's degree. I further certify that I have resided for the entire period within the state of Orissa between the dates of registration and submission of thesis.

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For Mandākini, my beloved wife

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EXORDIUM

Experience is its own justification. Twenty -five years ago – I had developed a habit of staring at the morning sun until it became quite bright. In course of my beholding, one day, I caught sight of a reflection on the solar disc, which seemed none other than that of the Sun Temple of Konārk ; it lasted for a few seconds, although it was far away from the place of my vision. This televisual experience pertaining to the fact that the solar disc is a reflecting surface or a cosmic mirror through which terrestrial as well as celestial images can be viewed according to the situation was so captivating that I anxiously went about in search of similar experience of some other persons, if any, in support of its reality. *A Study of the Siddhānta Darpana* was a part of the search.

But soon I realised that the fool in me was rushing where angels had feared to tread. Neither I had the requisite expertise in astronomy nor the proficiency in Sanskrit to go through the stupendous work of Samanta Chandrasekhar. After a long striving for getting the basic minimum, there are still reasons to fear that the feeling of anyone who may examine this study of mine will be one of wonder at my boldness. Thank heavens! Translations of the *Siddhānta Darpana* in Oriya, Hindi, and English were brought to light one after another by different authorities perhaps with the sole purpose of removing my difficulties.

Ancient Indian astronomy has ever been subsumed in the study of natural laws and phenomena that presuppose the metaphorical impossibility, e.g. 'No non-poetic account of reality of Nature can be complete.' But present-day discussions on this type of treatises have regrettably been

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restricted within the ambit of mathematics unto which, of all persons, Einstein had quipped: 'I do not believe in mathematics' (Barrow 1999: 207). The most important aspect of a *Siddhānta*, i.e. the characterised depiction of God and the Nature, which has so far been superciliously overlooked as an extraneous matter warrants an exactment and the present work is an humble endeavour in that direction.

Unlike in the past, we find nowadays a detrimental lack of complement between poetry and astronomy, dealing unashamedly with the sky as it is experienced by the ordinary observer through naked eye, standing under the stars. No telescope is essential to the understanding and enjoyment of the heavenly bodies. Samanta Chandrasekhar's introduction to the skies had fortunately come to him through nature's eyes alone and not through any telescope which would have surely restricted his playful flight of imagination and freewill. Astronomy as an avocation had furthered his poetic capabilities in contemplating truth, goodness, beauty and, above all, the Universe, the creator, and the creatrix. Thus, I contend, Samanta Chandrasekhar had wanted to reaffirm people's faith in a theory of literature which might be appropriately called 'astropoetics', in which the poet's eye is not merely a photographic camera. Vision is an active and not a passive process as the ancient theory of emission of visual rays from the eye directly suggests the active part played by the observer in visual perception. The speed of sight is more important in astropoetics rather than the speed of light.

This is also a study of an astronomer-poet's idea of God and the spiritual aspect of astronomy. Animism is the ancient version of the modern theory of correspondence as it has been proposed later by Baudelaire. Accordingly, astronomical symbols are divine correspondences with the human mind that is sufficiently aroused so as to decipher

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these properly. Mathematics is nothing more than an instrument of such decipherment. By the end of my study, I hope it will convince the reader that there is more in astronomy than the ordinary commentaries.

I am thankful to the authorities of Berhampur University for granting the permission to undertake this research work independently for the award of the degree of DLitt. I am also thankful to the authorities of the UGC for the financial aid for this research project. I owe deep debt to those writers whose books I have utilised in the composition of my thesis and also to Dr K K Gandhi who has painstakingly gone through the manuscript and has pointed out my errors.

Puri
15 May 2001 Prasanna Kumar Patnaik

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Chapter I

THE GEOMETERS' ASTROPOETICS

Magic was the prehistoric breeding ground from which the twin sisters – arts and science – were born. To understand the universe and to acquire power over it, esoteric ritualism was the most effective operation of all ancient civilisations. Only three hundred years ago when the scientifi c revolution of the seventeenth century took the final decision to dissociate itself from the supernatural bickerings, science separated itself from esoterism.

Imitation and animism, as it were, are the first great pre-scientific method and the first great pre-scientific hypothesis respectively, and poetry, even today, rests on both. From this point of view poetry may be regarded as an ancient method. Some amount of affinity may still be found in the mental process of scientists and poets at certain critical stages of their inquiry or discovery.

The aim of poetry is ever postulated within two extremities: 'an end in itself' and 'the means'. One extremity suggests that poetry should be a way of life, a purpose neither ethical nor factual, nor subject -oriented, nor along with any missionary tract, nor even guided by any scientific temper. It should be beautiful and useless. There should not be, as Yeats has said, any brooding over scientific opinion which has extinguished the central flame in Tennyson. The other extremity declares that truth can be knowledgeable by means of science alone and poetry should be transformed accordingly. Ancient astronomical literature conforms to the latter. Numerous examples can

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be cited from the Vedas in support of the latter category, such as:

Atharbānāyāsvinā Dadhîchisvayam sirah
pratyairāyatam
Sa bām madhu pra bochdrutayam twashtram
yad dasrāvapikaksam bām.

R V I, 117, 22

You replaced, Aśvins, with the head of a horse, (the head of) Dadhîchi, the son of Atharvan, and true to his promise he revealed to you the science of *madhu* (spring) which he had learnt from Twashtra and which was a jealously guarded secret.

P C Sengupta has interpreted the above lines in the following manner:

These lines of Rig Veda suggest to us that the science of spring or *madhuvidyā* was nothing but the knowledge of the celestial signal for the coming of spring. What that signal was is now the matter for our consideration. The A śvins are always spoken of and addressed in the dual number. The Vedic rishis most probably identified the Aśvins with the stars α and β Arietis – the prominent stars of the naksatra Āsvini. Whether this be true or not this much is certain that the Aśvins were and are even now regarded as the presiding deities of this naksatra Āsvini. The three stars α, β, and γ Arietis form a constellation which is likened to the head of a horse. The Aśvins are spoken of as riding in the heavens in their triangular, three-wheeled, and spring-bearing chariot, in several places in the Rig Veda some of which are: (i) Three are the solid wheels of your spring-bearing (*madhuvāhana*) chariot, as all the gods know it to be when you attended on Vena (= Venus?) the beloved of Moon (*trayah pawāyo madhuvāhane rathe somasya venāmanvisva idva viduh* (Rig Veda (1, 34, 2)) (ii) May the three -wheeled car

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> of the Aśvins which is the harbinger of spring (*madhuvāhana*), drawn by swift horses, three-canopied, filled with treasure and in every way auspicious, come to our presence and bring prosperity to our people and our cattle. *Arbang trichakro madhu bahano ratho jirasvo Asvinoryatu sustutah tribandhuro mādhava visvasoubhagah sam na abaksyadba dvipade chatuspade.* (Rg Veda 1, 157.3)
>
> *Ancient Indian Chronology*,
> University of Calcutta, 1947, p.62

Thus the *madhuvidyā* or the science of spring was nothing but the knowledge of the celestial signal for the advent of spring and the heliacal rising of the stars α, β, and γ Arietis. Of these three, Arietis rises last. Hence the Aśvins rise completely when α Arietis rises. How wonderfully the celestial phenomena had turned the ancients to be astronomer-poets!

Similarly, P C Sengupta has interpreted the lines of the Rig Veda in which Indra becomes Maghavan (Rig Veda 1.32/10.23) as follows:

> *Indro Maghairmaghavā Vrtrahā bhubat* (10.23.2) (Indra by (the heliacal rising of) the *Maghās* became Maghavan, and thus became the slayer of Vrtra).
>
> Here the word 'Maghavan' means 'one that owns *maghā*'; the word '*maghā*' to us means the constellation *Maghās* consisting of the stars α η β γ δ μ and e Leonis. We understand when at the latitude of Kuruksetra, the most prominent star Leonis of this group became first visible in the east at dawn, the sun reached Indra's place or the summer solstice. We cannot accept that the word '*Maghā*' can mean anything else than the constellation *Maghā*. If Indra is 'a personification of a phenomenon of the firmament (Wilson's Introduction to his Rig Veda Translation), and "Vrtra" or "Cloud" is also another phenomenon of the firmament, the word "*maghā*" must

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> also mean another phenomenon of the same firmament, viz., the constellation *Maghā*. Besides, if "*Maghā*" be here taken to mean "wealth", its acquisition cannot possibly increase the fighting capability of this Indra' (Ibid., p.76). Before the heliacal visibility of α Leonis or *Maghā*, the constellation of *Aśleṣā* or *Ahi* i.e., Hydrae became first visible. *Vṛtra* is also called *Ahi* in the Rig Veda; the allegory implied is perhaps that *Ahi* means the clouds that were seen in the sky from the rising of *Ahi* or *Aśleṣā* which did not yield rain till the rising of *Maghā* (Regulus)... One thing more that strikes us in this connection is that the so-called horse of Indra was most probably the constellation Leo, which is ordinarily likened to a lion. It may be likened to a horse as well. (Ibid., pp.80–81)

Similarly the Vedic myth of the Rbhus and their awakening by the Dog (R V 1.20: 1.161, 11, 13, etc.) has been interpreted by Sengupta as follows:

> Here the sun is taken to exhort the Rbhus reposing in his orb to clear up the sky on the call of the Dog. We are inclined to take that the call of the Dog means the heliacal rising of the Dog Star or α Canis Majoris, Sirius or the Sothis which was the Egyptian name of the star.
>
> Ibid., p.86

But the mythical passages were nevertheless poetic:

> *Supuvāṁsah rbhabastadprchhatā*
> *gohyakah idam noh abu budhat,*
> *Swānam vasto bodhayitaramabrabout*
> *Sambatsarah idamadyā byakhyat.*
>
> 1.161.13

'Rbhus, reposing in the solar orb, you inquire "who awakens us, unapprehensible (unconcealable) sun to this office of sending rain?" The sun replies, "the awakener is the Dog and

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in the year you again today light up this world".'

Sengupta has gone up to calculating from within the Vedic myth (R V, v. 40/5–9): (When O' Surya, the son of Asura Svarbhānu overspread there with darkness, the world is shone lustreless like a confounded tactless person, etc.) 'that the time of the solar eclipse spoken of in the Rig Veda is thus obtained as 26 July 3928 BC' (Ibid., p.116). Likewise, he has deduced that in the Atharva Veda (*Udgātām Bhagawati Vicrtou nāma tārake*, / Tr. Arisen are the two blessed stars called the unfasteners, (*Vicrta*) let them unfasten (*Vimuc*) of the Ksetriya the lowest, the highest fetter/ AV 11, 8, 1/Whitney's) the heliacal rising of two stars λ and ν scorpionis is mentioned suggesting the beginning of the season *hemanta* or the dewy season.

To take another example, the phenomenon of Prajāpati meeting his daughter Rohini is thus stated in the Rig Veda (x.1.6): 'When the deed was done in "Mid-heaven" in the proximity of the father working his will, and the daughter coming together, they let the seed fall slightly; it was found upon the high place of sacrifice.' (Wilson)

To quote Prof. P C Sengupta, 'The astronomical phenomenon was observed in mid-heaven or on the meridian of the observer. We have a star called Prajāpati in the *Surya Siddhānta*, viii, 20, which is identified by Burgess in his translation, with δ Aurigae, and his identification is faultless. We have also the Mrgabyādha (Sirius) of which another Vedic name was Svān (Dog), and Rohini is of course the star Aldebaran.'

The legend divested of allegory is that the stars δ Aurigae and α Tauri or Aldebaran were observed to cross the meridian almost together. This was understood by the Gods as the most improper conduct on the part of Prajāpati and the God Rudra, then born and stationed at the star Sirius, pierced Prajāpati (δ Aurigae), his three-pointed arrow was

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most probably the line through θ, β and δ aurigae, which have almost the same celestial longitude. Again the star Sirius, the three stars at Orion's belt and α Tauri or Aldebaran are very nearly in the same line. Here Rudra's three-pointed arrow may also mean this latter line through Orion's belt. But who could deny the poetic excellence of this Vedic couplet?

Madhyā yat kartvamabhavadabhike kāmam
krnvāne pitari yubatyām
Manānagreto jahaturviyamtā sānou
nisiktam sukrtasya yonim.

R V X.61.6

These lines are not to be brushed aside as a statement of pseudo-science because they are discernibly scientific, as well as poetic too. It would not be improper to say that the Vedic seers were, nevertheless, aware of the fact which Prof. John D Barrow along with John Myhill has had to admit as the metaphorical impossibility. The aphorism says 'No non-poetic account of reality can be complete.' Prof. Barrow has explained:

> Some attempts have been made to create a metaphorical extension of the insights of Gödel and Turing in order to reveal what sorts of things in our experience might be outside the grasp of formalisms and limits. In 1952 the American logician John Myhill produced the most interesting of these. Myhill classified possibilities by borrowing some terminology from mathematical logic and dividing ideas into three classes: 'effective', 'constructive', and 'prospective'. ...Not every attribute of things is listable or computable. The property of being a true statement of arithmetic is an example. Attributes which are neither listable nor computable are called 'prospective', they can be neither recognised nor generated in a finite number of

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> deductive steps. They show that there is a place for ingenuity and novelty. There are things which cannot be encapsulated by any finite collection of rules or procedures. Beauty, simplicity, ugliness and truth are all prospective properties. There can be no magic formula that can generate all possib le examples of attributes like these, even in an infinite lifetime. They are inexhaustible. No program or formula can generate all examples of beauty or ugliness, nor can any program recognise them all when it sees them, and nor can we in any way that the romantics imagined. In Myhill's words, 'The analogues of Gödel's theorem for aesthetics would therefore be: There is no school of art which permits the production of all ugliness.'
>
> Prospective properties are beyond the reach of mere technique. They are outside the grasp of any Mathematical theory of Everything, that is why no non-poetic account of reality can be complete.
>
> Barrow 1999: pp.215–216

This type of metaphorical impossibility so to say, had peremptorily prompted the Indian geometers to administering poetic elements in astronomy which brought about a different kind of poetics known as the 'Siddhānta'.

It was not the case in India alone. In France too, some critics of Addison's day had the disillusioning candour to style themselves 'geometers', or to boast of their 'esprit geometrique'. For instance, the statement of the Homeric critic Terrasson might be considered: 'The way to think about a literary problem is that pointed out by Descartes for problems of physical science. A critic who tries any other way is not worthy to be living in the present century. There is nothing better than mathematics as a propaedeutic for literary criticism.' (Austin Warren, *Alexander Pope as Critic and Humanist*, Princeton, 1929, p.17) (*Dissertation critique sur L 'Iliade d' Homere*, 1715 Preface, p.65)

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It has been a widespread misconception that ancient Indians, though cultivating philosophy and literature from a very early period and surpassing almost all the ancient civilised nations in respect of those two disciplines, utterly neglected the search for truth in the world of matter, and hence made no considerable advancement in the field of physical sciences. It is needless to say that the misconception is dee ply embedded in the minds of those who deliberately ignore and neglect the scientific literature of ancient India. Proofs to establish the fact that Indians occupied the foremost place in the field of mathematics – the exact science and its logical corollary, astronomy – are not far to seek. In spite of very many endeavours to prove that Indians had received their preliminary lessons in Mathematics and astronomy from foreign preceptors, now it is not much difficult to prove that Indian Mathematics and astronomy had a thoroughly indigenous origin. The foregoing statement is made with no pretension to deny the foreign influences, especially that of ancient Greece, on later systems, and that influence may unhesitatingly be admitted as a result of normal 'give and take' which was quite possible when two great cultures came closer to each other. Prof. G R Kaye has discordantly remarked:

> The point of departure in the study of almost any section of knowledge in which India is deeply concerned is the Rig Veda; and in this India is indeed fortunate, for of all the literature of early civilisation the Rig Veda is perhaps the most fascinating to the philosophic enquirer, and in particular, the Vedic Hymns that are devoted to celestial phenomena are amongst the most beautiful. But these Hymns are concerned with the attributes and functions and praise of certain divinities who are only very loosely connected with heavenly bodies or phenomena; and the astronomical information exhibited in these hymns is by no means their essential part.
>
> *Hindu Astronomy*, 1924, p.11, Cosmo Publication, reprint 1981

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But he has admitted, 'It was not until the beginning of the nineteenth century that the attention of European scholars was drawn to those portions of Vedic literature that contain, in somewhat romantic and vague expression indeed, the true essence of indigenous Hindu astronomy.' (Ibid., p.1)

Since 1691 when Giovanni Dominico Cassini published an account of certain astronomical rules brought from Assam by M de la Loubiere and soon after in the *Historia Regni Graecorum Bactriani* of T S Bayer some account of Hindu astronomy was given, European scholars had started to take interest in it. As a result *Traite de L' astronomie Indienne et Orientale* (1787) of Jean Sylvain Bailly, *Mecanique Celeste* (1802) of Laplace, articles of Playfair in *Asiatic Researches* (1790, 1792), articles of John Bently and S Davis in *Asiatic Researches* (1790, 1792, 1799), Colebrooke's article in *Asiatic Researches* (1807), translation of the *Surya Siddhānta* by W D Whitney and E Burgess (*Journal of the American Oriental Society*, 1858), H R Hoisington's *Oriental Astronomer* (1848), translation of the *Pañcasiddhantika* by G Thibaut (1889) along with a number of articles written by many other scholars in different journals had come out. These contributions settled definitely the question of the connection between the later Hindu astronomy and that of the Greeks, and therefore the attention of the orientalists was consequently directed to the Vedic period. In 1893, Jacobi and Tilak independently suggested that the Vedic works contained important astronomical evidence of their own antiquity.

Science, Art, and Religion, evolving to new insight from their starting place in the mind of primitive man, are inseparable processes. They are all techniques of knowledge operating with equal validity at different levels of awareness. The Pilgrim Fathers of the scientific imagination as it exists in the Vedas herald the vista where modern poets as well as scientists can sit together to meditate upon. As Einstein says:

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> The most beautiful thing we can experience is the mysterious. It is the source of all true art and science. He, to whom this emotion is a stranger, who can no longer pause to wonder and stand rapt in awe, is as good as dead; his eyes are closed... to know that what is impenetrable to us really exists, manifesting itself as the highest wisdom and the most radiant beauty which our dull faculties can comprehend only in their most primitive forms – this knowledge, this feeling is at the centre of true religiousness.
>
> *The Lincoln Library of Essential Information*, vol. II, p.1473

It is frivolous to allege that the hymns of the Veda are merely the sacrificial compositions of a primitive and still barbarous race written around a system of ceremonial and propitiatory rites, addressed to personified powers of Nature and replete with a confused mass of half-formed myth and crude astronomical allegories yet in the making. Rather, as in Europe, where the Orphic and Ele usinian mysteries prepared the rich soil of mentality out of which sprang Pythagoras and Plato, a similar threshold is at least probable for the later march of thought in India.

It was the curiosity of a foreign culture that broke, after many centuries, the seal of final authoritativeness which Sāyan had fixed on the ritualistic interpretation of the Veda. The ancient scripture was delivered over to a scholarship, laborious and bold in speculation, ingenious in its flights of fancy, conscientious according to its own lights, but ill-fitted to understand the method of the old mystic poets; for it was void of any sympathy with that ancient temperament, unprovided with any clue in its own intellectual or spiritual environment to the ideas hidden in the Vedic figures, parables, symbols, and imagery.

We have to recognise, in fact, that there is an enormous gap between the empirical and the exact physical sciences and the transdisciplinary amalgamated knowledge upon

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which Vedic consciousness lies. Those who are not as inspired as the Vedic seers, nor depend on inner experience and the suggestions of the intuitive mind for all knowledge that ranges beyond mankind's ordinary perceptions and daily activities, can never be illuminated so as to appreciate the Vedic scaffolding for science. No pursuit of aesthetic grace, richness, or beauty induces these mystic poets to vary the consecrated and esoteric form which has become for them a sort of divine mathematics transmitting the eternal formulae of the universe to the continuous succession of the initiates. In this regard, nothing can be more illuminating than the following remarks of Yāska in his epilogue to the Nirukta: 'Concerning the mantras, none can claim to have perceived their truths if one is not a seer and a spiritual energiser…' (Nirukta, XIII.12)

Taken in conjunction with Tilak's works such as *The Arctic Home in the Vedas* (1903, Bombay) and *The Orion* (1893, Bombay), Swami Dayānanda's *Satyārth Prakāsh* (1935, Veda Tattvaprakāsá, Arya Sahitya Bhawan, Delhi), serves as the starting point for the new rational interpretation of the old scripture which explains much that has hitherto been inexplicable and recreates for us the physical origins, if not the actual physical environment, of the old Aryan world.

Dayānanda's endeavour was aimed at proving the idea that the Vedas were a plenary revelation of religious, ethical as well as scientific truth. Its religious teaching was monotheistic and the Vedic Gods were different descriptive names of the one deity; they were at the same time symbolic of its powers as they were seen working in Nature and by a true understanding of the sense of the Vedas we could arrive at all the scientific truths which have been discovered so far. On Dayānanda's interpretation of the Vedic hymns, Sri Aurobindo has remarked:

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> That the ancient races were far more advanced in the physical sciences than is as yet recognised may also be admitted. The Egyptians and Chileans, we now know, had discovered much that has since been rediscovered by modern science and much also that has not been rediscovered. The ancient Indians were, at least, no mean astronomers and were always skilful physicians; nor do Hindu medicine and chemistry seem to have been of a foreign origin. It is possible that in other branches also of physical knowledge they were advanced even in early times. But the absolute completeness of scientific revelation asserted by Swami Dayānanda will take a great deal of proving.
>
> *The Secret of the Veda*, p.20

When the astronomical information of India first became known in Europe, the extraordinary light, which they appeared to cast on the history and antiquity of the East, made a great impression everywhere; and men engaged with eagerness in a study promising that mixture of historical and scientific research which is the most attractive of all. But a more minute examination led the European enquirers to doubt the so-called 'pretensions to high antiquity found in the astronomical books of the Hindus'. It was alleged: 'The data are no where quoted from which the Indian tables were computed and there is no record, not even any tradition, of regular astronomical observations having been made by the Hindu.' (Delamber's argument quoted by Playfair, trs. Roy. Soc. Edinburgh, vol. ii, 1790, pp.135–192, cf., *Hindu Astronomy*, G R Kaye, p.2)

This type of allegation regarding the origins of Indian astronomy has been predictably dealt with in the Veda itself:

> He who has created this does not comprehend it: he who has beheld it has it also verily hidden from it: he, whilst yet enveloped in his mother's womb, is subject to many transformations.

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The heaven is my parent and progenitor: the navel of the earth is my kinsman: the spacious earth is my mother. The womb lies between the two uplifted ladles, and in it the parent has deposited the germ.

I ask thee, what is the uttermost end of the earth? I ask thee, what is the fecundating power of the rain-shedding steed? I ask thee, what is the supreme heaven of the Word?

This altar is the uttermost end of the earth: this sacrifice is the navel of the world. This *soma* juice is the fecundating power of the rain-shedding steed. This Brahmā is the supreme heaven of the Word.

The seven worlds sustaining the embryo for half a year, the fecundating element of the world abide, by appointment, in the various functions of the All-Pervading. By their intelligence they pervade in thought all around.

I distinguish not if I am all this, for I go perplexed and bound in mind; when the first-born perceptions of the truth reached me, then immediately I obtain a portion of that Word.

The immortal, cognate with the mortal, affected by the desire of enjoyment, goes to the lower or the upper sphere. But men beholding them, associated, going everywhere in this world together, going everywhere in other worlds together have comprehended the one, but not the other.

All the gods have taken their seats upon this supreme heaven, the imperishable text of the Veda. What will he, who knows not this, do with the Veda? But they who know it, are perfect.

Cow of the Word, may you be rich in milk through abundant fodder, eat grass at all seasons, drink pure water and roaming at will, so that we also may be rich.

The word has been uttered like the rumbling of the clouds, fabricating the waters and being one-footed, two -footed, four-footed, eight-footed, nine-footed or thousand -footed in the highest heaven.

From the Word of the celestial cow-like clouds comes abundant rain, and thereby the people of the world live,

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> thereby the life-giving energy spreads to the grain, and the universe exists.

> Four are the definite grades of the Word, those who know the Brahmā know them, three deposited in secret are unseen and unheard of, men speak the fourth grade of the Word.

> The fellies are twelve, the wheel is one, three are the axles; but who knows it? Within it are collected three hundred and sixty spokes, which are, as it were, movable and immovable.
>
> Rg Veda 1, 164, 32–48
> adapted from Wilson's translation

From this hymn it is evident that astronomy also pertains to the transcendental principle of Vāc, the creative Word 'which covers the diverse poises of the expanding consciousness as the thousand vastnesses of the spirit manifest themselves in a thousand ways' (Rig Veda X.114.8). According to Yāska, 'The seers were men who had the direct experience of the primordial Reality' (Nirukta 1.20), and as Srimad Anirvān says:

> Its real nature, like that of Vāc, will be revealed only when, with a clear grasp of this identity, one moves up the stream to its source in simple intention. A simple intention of an integral whole, symbolically described by the seers as the flash of lightning, is the original motif which is gradually filled in with details of forms. The whole is an explosive idea, an a priori fact, the measure of whose reality is in the ineffable intensity of perception. Its deployment in inner forms is decidedly not according to a rigid evolutionary pattern. One must remember that every spiritual movement is essentially a regression, and not a progression; it is a

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> moving back from the manifest to the unmanifest. And paradoxically speaking, the unmanifest may manifest itself at any stage of the mental evolution in its fullest intensity: herein lies the mystery of mysticism.
>
> *The Cultural Heritage of India*, vol. I, p.329
> Rama Krishna Mission Institute of Culture, Calcutta, 1993

It is needless to add more arguments to justify that Vedic astronomy too is one of such manifests. But mention must be made as to how, without proper knowledge of observational astronomy, certain Vedic passages are likely to be misinterpreted. The method of the Vedic Hindus for determining the solstice days is expressed in the *Aitareya Brāhmna* as follows:

> They perform the Ekavimsa day, the Visuvan; in the middle of the year. By this Ekavimsa day the gods raised up the sun towards the world of heaven (the highest region of the heavens, viz., the zenith). For this reason this sun (as raised up) is called Ekavimsa, of this Ekavimsa sun (or the day), the ten days before are ordained for the hymns to be chanted during the day; the ten days after are also ordained in the same way; in the middle lies the Ekavimsa, established on both sides in the Virāj (a period of ten days). It is certainly established in the Virāj. Therefore, he going between (the two periods of ten days) over these worlds does not waver.
>
> *A B 18*, tr. by Keith, quoted by S B Dixit in his
> *Bhāratiya Jyotih Shastra*, p.47

Deciphering the meaning of the passage, P C Sengupta has commented that Sāyan has failed in his exposition of this passage which relates to observational astronomy and no one who is unacquainted with this branch of science can possibly bring out any sense of it. (*Ancient Indian Chronology*, p.155, 1947, Calcutta University)

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It may be noticed that the Vedic root of astronomy gave out two offshoots, namely mythological cosmogony and scientific cosmology. The former gave rise to a body of literature which was known as the Purānas and the latter gave rise to a body of literature which was known as the *Vedānga*. All the five attributes of the Puranas are cosmological denominations, such as: (a) *Sarga* (creation of the Universe from its natural cause), (b) *Pratisarga* (recreation of the world from its constituent elements, in which it is merged at the close of each aeon – *Kalpa* – or day in the life of Brahmā, the creator), (c) Vamsa (genealogies of gods, demons, patriarchs, sages, and kings – especially of the last two), (d) *Manvantara* (cosmic cycles, each of which is ruled over by a Manu, the first father of mankind), and (e) *Vamsānucarita* (accounts of royal dynasties).

Jacobi remarks: 'Notwithstanding, or rather because of its visionary character, Puranic cosmography became, as it were, an article of faith. The general belief in it was not shaken even by the introduction of scientific astronomy, though the astronomers tried to model the traditional cosmography on the basis of their science' (*Encyclopaedia of Religion and Ethics*, iv, p.160). In order to illustrate the nature of mythological cosmogony, the twenty-second and twenty-third *adhyayas* of fifth *skanda* of *Srimad Bhāgabatam* may be quoted in whole which have been designated as 'Narration of the celestial sphere' and 'Narration of the constellation Ursa Minor' respectively. The seven great islands are surrounded by the seven great seas. Jambudvipa is the centre of all these, and in the centre of this is the golden mountain Meru. The height of Meru is 84,000 *yojanas* and its depth below 16,000. Its diameter at the summit is 32,000 *yojanas* and at its base 16,000. This mountain is like the seed cup of the lotus of the earth... The orbit of the sun is 100,000 *yojanas* from the earth and that of the moon. At an equal distance above the moon is the sphere of the stars.

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Mercury is 200,000 *yojanas* beyond, Venus 200,000 further still, Mars 200,000, Jupiter 200,000, and Saturn 250,000 *yojanas* beyond Jupiter. The sphere of the seven rishis is 100,000 *yojanas* beyond and at the same distance above is Dhruva, the pivot or axis of the whole planetary circle. Beyond Dhruva are the four heavens... on Dhruva rest – the seven great planets, and on them depend the clouds. As Dhruva revolves it causes the moon, the sun, and the stars to turn round also, and the naksatras follow in its circular path, for all the heavenly bodies are, in fact, bound to the polar star by aerial cords... *Visnu Purana*, 2.29

These quasi-astronomical passages only exemplify a general mental tendency which displays itself in almost every department of Hindu literature, but mere dogmatic assertion appears more than ordinarily misplaced in an exact science like astronomy. It is intriguing to see the transmissions involving astronomers, mathematicians, and the authors of early Puranas. Astronomers used enormous figures for their calculations, figures which are identical with those in the cosmology of the Puranas. Did the astronomers borrow these figures or the *paurānikas* take their cue from the astronomers? To this question Romila Thapar answers:

> Astronomy and mathematics were not only privileged in Indian society at the time but there were also dialogues with counterparts in the Hellenistic world and later with China. Possibly the authors of the Puranas in con structing their cosmology were peppering it with items from what were regarded as superior branches of knowledge, intending thereby to associate their construction with the authenticity attributed to astronomy and mathematics.
>
> *History of Science and the Oikoumene*, cf., *Situating the History of Science*, ed. S Irfan Habib and D Raina, Oxford University Press, 1999, p.25

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The *Vedanga Jyotiṣa*, propounding the doctrine as taught by Lagadha, has thirty-six verses in the Rig Vedic recession and forty-three in the Yajur Vedic one, thirty being common to both and is marked by a difference which can be termed as formal astronomy. The post-Vedic works on astronomy like the *Vṛddha Garga Saṁhitā*, the *Surya Prajñāpti*, the *Taittiriyasaṁhitā*, the *Maitrāyani* and *Kāthaka Saṁhitās*, etc., had paved the way for the streamlined compositions known as *Siddhantas*. The real line of difference between the *Purānic Jyotis* and the *Vedanga Jyotiṣa* has been diligently drawn by Prof. P C Sengupta in his *Ancient Indian Chronology* from which the following passage, for instance, might be referred:

> We have thus most carefully examined the Puranic evidences as to the date of the Bhārata battle. We have established that the oldest Puranic strata are to be found in the *Matsya Purana*, then comes the *Vāyu Purāna* in sequence of time. In so far as historical matter is concerned the *Visnu* and *Bhagavata Puranas* are not at all trustworthy. Even in the *Matsya Purana*, the dynastic list of the Brhadrathas of Magadha is incomplete, as in that it states the names of the chief kings only and the durations of their rules. We have also seen that the Puranic summarisers really mean that the time interval between the birth of Pariksit and the accession of Mahāpadmānanda was about 1500 years. The Visnu and Bhagavata summarisers' statement that the same period was about a thousand years is not reliable as it contradicts the dynastic lists of these Puranas and is not acceptable even to the great scholiast Sridhara of the *Visnu Purana*. The incomplete dynastic lists of the *Matsya Purana* properly interpreted may lead us to 2321 BC as the year of Bhārata battle. Any speculation with such faulty materials as the Puranas afford can never lead to the real truth about the year of the Bhārata battle. On the other hand much better data have been derived by us from the Mahābhārata itself which directly lead us to 2449 BC as the year of the

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> Bhārata battle and this was the zero year of the Yudhisthira era according to the Vrddha Garga tradition. We have also given the most careful consideration to the Puranic description of the position of the Great Bear in Pariksit's time. This only leads us to the year 371 BC – a most hopelessly absurd result. Hence the Puranic evidences taken as a whole are incomplete and cannot lead us to the real year of the Bhārata battle. We trust our interpretations of all these evidences would be found to be rational and compare favourably with those given by Pargiter, Dev, Ray, Bose and others.
>
> Sengupta, 1947: 58–59

The *Vṛddha Garga* tradition as referred to in the deductive passage above, corroborates the *Vedanga Jyotiṣa* as a whole, to be the earliest formal work on Hindu astronomy. According to tradition *Vṛddha Garga* was the earliest Indian astronomer and his name is mentioned in the Mahābhārata (IX.37, 14–17, XII 59.111). At the time of compilation of the Mahābhārata in its present form (c. AD 400) Vrddha Garga had already been regarded as a great Indian astronomer. Lagadha, the author of the *Yājusa Jyautisam*, was older than *Vṛddha Garga* according to Bhattotpala's commentary on *Brhat Samhitā* (111.4). Parāsara, the author of the *Parāsara Samhitā*, lived very probably in the third century AD and he lived after Garga. Names of astronomers like Rsiputra, Kapilācārya, Kasyapa and Devala are mentioned in Bhattotpala's commentary but nothing is known about them as yet. However, from the existing data, the period of formalisation of Indian astronomy can be safely assigned to be much prior to the advent of the Christian era. From the statement of the *Yajusa Jyautisam* as to the position of solstices, P C Sengupta's approximation yields that the year 1429 BC is the true date of the *Vedanga* tradition (Ibid., pp.189–190). The extract given below may be contrasted with the less accurate Puranic statements on astronomy:

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Swarākramete Somārkou yadā sākam savāsavou
syāt tadādiyugam māghastapah shuklo' yanam hyudak
prapadyete sravisthādow suryā candramasaudak
sārpārdhe daksinārkastu maghasravanayoh sadā.

Yajusa Jyautisam, 6–7

When the sun and the moon rise up together with the naksatra *Dhanisthā*, that time (or event) marks the beginning of the *Yuga* (five yearly lunisolar cycle), of the lunar month of *Māgha*, of Tapas (or the first month of winter), of the light half of the month and of the beginning of the sun's northerly course. The sun and the moon turn north at the beginning of the naksatra *Dhanisthā* and the sun turns south at the middle of Aslesā division. These take place always in the lunar month of *Māgha* and *Srāvana* (quoted from *Ancient Indian Chronology*, p.189).

This clearly shows that though the *Vedanga Jyoti sa* was the outcome of an incessant endeavour for depicting astronomical events more accurately than other works of literature, it was still in the garb of poetry.

Being adumbrated by the growth of *mahākāvyas* or epics, the formal astronomy of the *Vedangas*, for the sake of endearment among the people, transformed itself into an epic structure called the *Siddhānta*. The origin of the epics, as that of all forms of Indian literature, has been traced to the Veda, as a rule. According to Oldenberg, the *Sambāda* (dialogue) hymns of the Rig Veda (such as x.10 and x.95) as *ākhyānas* (ballads) are the source of the epics (*The Cultural Heritage of India*, II. 14). In the opening cantos of the Rāmāyana, Vālmiki styles it as a *kāvya*, a historical work, and an *ākhyāna* (The Rāmāyana (critical edition) 1.4.6/ 1.4.11/ 4.131.114). As the first epitome of a *kāvya*, it fulfils all requirements of a *mahākāvya* as defined in the works on poetics. In fact the definitions and attributes of the *mahākāvya*

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seem to have been framed according to the exploits of the Rāmāyana as a *kāvya*. In course of time, as the Vedic language became obsolete, it was superseded by classical Sanskrit as the vehicle of an ever-widening culture and new and varied forms of literature and thought.

The chief characteristics of a *mahākāvya* as have been drawn upon the aphorisms of Bhārata's *Nātyasāstra* by different later schools of poetics, is a paradigm shift from the Vedic concept of *kāvya* which had decidedly adhered to the principle of divinity and celestialism. Rig Veda defines both 'poet' and 'poetry' as *Sa kavih kāvya puru rupam dyauriva pusyati* (He is the poet who cherishes the acts of poets, as the heaven cherishes numerous forms: R V VIII 5.11.5) and *Yasmin visvani kāvya cakrenāviribāsrita* (In whom the universe of poetry is concentrated like the navel in a wheel: R V VIII 5.11.6). The Vedic concept of *kāvya* was inseparable from the Creator and the Creation, but ostensibly it turned out to be humanistic. A famous aphorism in the dramaturgy of Bharat, from which a systematic theory of poetics had emanated ever since, forms the point of departure of all later Indian aesthetic thought. It says, in essence, that the rasa is accomplished as a result of the conjunction of the determinants (*vibhāva*), the consequents (*anubhāva*) and the transitory mental states (*Vyabhicārin*) and it is said to be the quintessence of the *kāvya*.

This newfangled theory of rasa as the quintessence of poetry had appeared not as a bolt from the blue but as an abatement of the Vedic concept of *kāvya* in order to stage it mundanely. In the Rig Veda, it was avowed that: *Rasam te Mitro Āryamān Pivanti Varunah Kave, pavamānasya Marutah* (ix.3.4.24) (Mitra, Āryamān, Varuna, and the Maruts drink, Poet, thy juice, as thou droppest). Here the Creator was the sole determinant (*vibhāva*), and the celestial deities were the consequents (*anubhāva*), and intoxication (*moda*) was the transitory mental state (*vyabhicārin*). The wonder (*vismaya*)

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was the permanent emotion (*sthāyibhāva*) and the wondrous (*adbhuta*) was the rasa. In the Vedas, the rasa had been identified with the Supreme Lord: '*Raso vai sah rasam hyevāyam Labdhvā nandibhabati*' (He alone is the rasa) (Taittiriya Upanishad 2.6.1). It was avowed that: '*Esām bhutānām prthivi rasah prthivyā āpo rasah. Apamosadhayorasah ousadhinām puruso rasah purusasya vāgraso vāca rig rasa rucah sāman rasah sāmna udgitho rasah*' (*Chandogyopanisad* 1.1.2). This all-pervading rasa had to be contemplated cosmologically by the ways of the *Siddhānta*, but the dramaturgy and the poetics of Bharat had transformed it according to the needs of a performing art. The exactitude of the siddhantic conception of *kāvya* is obviously found to be in conformity with the Vedic concept. A stanza from the *Siddhānta Darpana* is noteworthy:

Dinabda krantyuttha trividha gatirityadiravane
Rsiddhā siddhānta drumaphal anivabhirvanitivih
Rasāsvādādāsām bhabatubhabatām tusta manasām
Rasābhrānit krānti ksitiratitaramā ratagiram.

S D, 17.151

By means of reasoning like the fruits of the *siddhānta* tree, theory of the earth's daily motion, annual motion and kranti has been disproved; may the tiredness of the people, caused by the revolution of the earth, be removed through the tasting of this rasa, i.e., the juice of the fruit.

It seems as if the antithesis between science and art is a false one, maintained only by the incurably, if enjoyably, sentimental.

So, in the days of yore a perfect blend of science and poetry had marvelled in the form called *Siddhānta*. But it was not until the advent of the age of scientific discoveries that literary criticism upheld such a transfiguration as desirable. In the West, Coleridge shared with the German nature

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philosophers the pious hope that science might someday graduate from its mechanistic bent and become reconcilable with an aesthetic view of the world. Wordsworth's best-known thought upon the subject appeared in the passage of his 1802 Preface to *Lyrical Ballads* where he lamented the contemporary separation of science from everyday life and its consequent repugnance to poetry, but allowed himself the hope that in future an all round reunion might occur. New poetic themes for the new generation of scientific bravos had also been prescribed in Christopher Smart's statement in 1759:

> For the tides are the life of God in the ocean, and He sends His angel to trouble the great DEEP.
>
> For He that fixed the earth upon arches and pillars, and the flames of hell flow under it.
>
> For the grosser the particles the nearer to the sink, and the nearer to purity, the quicker the gravitation.
>
> For MATTER is the dust of the Earth, every atom of which is the life.
>
> For MOTION is as the quantity of life direct, and that which hath not motion is resistance.
>
> For Resistance is not of God, but He hath built his works upon it.
>
> For the Centripetal and Centrifugal forces are God Sustaining and Directing.
>
> For Elasticity is the temper of matter to recover its place with vehemence.
>
> For Attraction is the earning of parts which have a similitude in the life.
>
> For the life of God is in the Loadstone, and there is a magnet, which pointeth due EAST.
>
> For FRICTION is inevitable because the Universe is FULL of God's works.

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> For the PERPETUAL MOTION is in all the works of
> Almighty GOD.
> For Newton nevertheless is more of error than of the
> truth, but I am of the WORD of GOD.
>
> Jubilate Agno, p.ix, II. 7–16, 35–6, 45 / qf.
> *Literary Criticism: A Short History*,
> Wimsatt: Brooks, 1957, p.430

Diderot in his *Salon de*, 1767 had stated: 'Poetry always contains a pinch of untruth. The Philosophic spirit gives us the habit of noting this untruth, and goodbye poetic illusion, goodbye poetic effect' (Ibid., p.414). Bidding farewell to the polish and languor, the external glitter and internal vacuity of the emotional and fanciful versification, poets and critics of the day had welcomed scientism as a substitute for fictionalism. C Day Lewis, a poet of the recent times has gone on record saying: 'Poetry may best act nowadays as corrective and complementary to science. ...Certainly the pictures which science shows to man of the universe he lived in, and of the universe within himself, offer the most amazing material for the poet to meditate upon. It would be a sad thing if no poets could be found to dwell upon it and give it imaginative meaning' (*The Poet's Way of Knowledge*, CUP, 1957, pp.30–31).

Exhortation by scientological aestheticians about why there ought to be any prevalence of science over poetry had perplexed a number of celebrated poets of the world and a good many of them were, nonetheless, modern. Coleridge went on to write:

> I look at the mountains
> (That visible God Almighty
> that looks in
> At all my windows)
> I look at the mountains
> Only for the curves of their outlines;

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The stars, as I behold them
Form themselves into Triangles –
And my hands
Are scarred with scratches
From a Cat, whose back I was rubbing in the Dark,
In order to see whether
the sparks from it
Were refrangible by a prism.

Qf. John Beer, *Introduction to Coleridge*,
Everyman's Library, 1963

So also Walt Whitman:

When I heard the learn'd astronomer
When the proofs, the figures, were
ranged in columns before me
When I was shown the charts and
diagrams, to add, divide, and
measure them,
When I sitting heard the astronomer's
where he lectured with much applause
in the lecture room
How soon uncountable I became tired and sick
Till rising and gliding out
I wander'd off by myself,
In the mystical moist night air,
and from time to time
Looked up in perfect silence at the Stars.

Cf., *Literature*, Better Reading, 2, Blair and Gerber,
Scott, Foresman and Company, USA, 1948

It is needless to say that these poems are not proper astronomy, but nevertheless, are on the borders of astronomy. Contrary to the conflicting state of mind reflected in these poems we find the most appropriate example in Tagore's *Visva Parichaya*, which stands for a poet's unequivocal commitment to the study of astronomy.

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In his apology, addressed to Sir S N Basu – the famous Indian astrophysicist, Tagore has explained:

> It is urgent that those who have begun their education should be allowed from the very start to enter the outer gate of science if not quite into its threshold. It is here that literature can help to pave the way for science, and for this, science need feel no compunction. It is with this sense of responsibility that I have undertaken this work, though I am aware that I am answerable not only to literature but to science as well. ...Needless to say I am no devotee of science, but since childhood I have always been curious about it, deriving endless pleasure from it. I remember when I was about nine or ten years old, often on a Sunday, Sreejut Sita Nath Dutta would pay us a visit. His stock of knowledge was not great, this I know today. But at the time when by demonstrating he would explain some very rudimentary truths about science to me, my eyes widened. ...My father used to point out the stars, the planets to me. More than that, he related to me in detail the distances of their orbits from the sun, the time they took in their revolution and so on. ...I found by then that I could use the English language quite intelligently and guess correctly. I would get hold of any scientific books on astronomy that I found easy to read. Sometimes the intricacies of mathematics would lead me on to rugged ground, but I would mercilessly drag myself over it. ...I started to read simpler books on astronomy. Many books on the subject were already published. The huge volume of Sir Robert Ball gave me great satisfaction. To follow it up, and much enthused, I read other authors like Newcombe and Flamryon – devouring them all from beginning to end. Then at one time I also ventured upon a set of articles on physiology by Huxley. Astronomy and physiology were the two subjects that had always engrossed my attention. This, I admit, was no profound learning, for it lacked the strength of a scholarly foundation. But being in constant

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touch through reading I naturally, developed a disposition to science.

Our Universe, tr. by Indu Dutta, Jaico, 1999, see preface

This admittance corroborates the conditions which had inspired the poets in writing the *siddhantas* at different times in the past. The *Visva Parichaya* of Tagore is also nothing but a modern day *siddhānta*, as it were, consisting of six astronomical essays, each preceded by a long poem. Tagore's keen interest in science had led him to several meetings with Albert Einstein in 1930. Tagore rejected science's claim to knowledge of an absolute reality. He was, however, sympathetic to science: 'Science offers us the mystic knowledge of matter which very often passes the range of our imagination.' But he disagreed with Einstein's view that the reality of the law-governed world by science which impels the scientist to rise above the hopeless chaos of the quotidian in order to glimpse the immutable and eternal world of mathematical structures, alone, is the true reality. Tagore believed that in its quest for objectivity, science 'tries to do away with that central personality in relation to which the world is a world... at its fatal touch the reality of the world is so hopelessly disturbed that it vanishes in an abstraction where things become nothing at all'. He said: 'Let us boldly declare that both facts are equally true. They belong to one truth which is their master.' Einstein's dream of an absolute, independent of human beings and subject to exceptionless causality, was shattered by the quantum theory. On the other hand, the artist's vision of science as a deeply human narrative came to the fore following the quantum revolution. Not s urprisingly, Ilya Prigogine and Isabelle Stengers see Tagore vindicated: 'The present evolution of science is running in the direction stated by the Indian poet.' (Tagore Contra Einstein, Ranjit Nair, View point, *The Times of India*, 6 July 1996)

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The upbraiding remarks of Tagore on his country's academic atmosphere at that time (1937) runs like this:

> In a country where there is continuous research in science, becoming fertile with an alive feeling in science, knowledge of it in fragmentary bits is being spread constantly. This is how one's heart's soil is quickened, becoming fertile with an alive feeling in science. It is the loss of it that has left our mind unscientific. We feel the impoverishment not only in our education, but also in the field of our occupation where we are bowed with frustration.
>
> Ibid., p.2

The statement had come out thirty-three years after the death of Samanta Chandrasekhar, the last important astronomer-poet of India. The regret with which Tagore had to contend composition of the *Visva Parichaya* remains at large even today. *Siddhānta Darpana* of Samanta Chandrasekhar, the last of its kind, heralds the end of an age-old literary tradition and Tagore's *Visva Parichaya* could not make an aftermath.

Before concluding the chapter, the famous maxim of Jean Mignot may be recalled: *Ars sine scientia nihil* (Arts without science is nothing). As humanists and individualists it flatters us to think that art is an expression of personal feelings and sentiments, preference and free choice, unfettered by the sciences of mathematics and cosmology. But mediaeval astropoetics was not like ours, 'free' to ignore truth. It might be seen that the greater part of modern science is also what the mediaeval thinkers would have called an art. Martin Johnson, in his book *Art and Scientific Thought*, convincingly says:

> Now much of the concern of the modern physical scientist, atoms, electrons, atomic nuclei, electron waves,

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etc., is essentially not of a nature to be directly known to sight, touch, or hearing. These 'things' are as far from being objects of direct sense perception as anything imagined by the most fantastic of artists. If the latter justifies himself by the coherence of the communicated ideas to which his patterns give rise, where is he resembling and where is he differing from, the physicist whose view of the universe is a deliberately woven structure of ideas which also radically diverges from sense perception?

Qf. C Day Lewis, *The Poet's Way of Knowledge*, CUP, 1957, pp.15–16

Now, it is no wonder that Maya, the Great Asura to whom the authorship of the foremost treatise on astronomy is ascribed in India, has been addressed as a *mahakāvi* (great poet) in the Mahābhārata:

Aham hi Visvakarmāvai dānavānam mahākavih
Soham vaitvatcrte kartrm kinchidicchāmi pāndavah.

Sabha Parva, 1.5

Also Varāhamihira (c. AD 600) has termed his book on astronomy as *kāvya*:

Durjana hutāsataptam kāvya suvarnam
visuddhimāyati, srāvayitavyam tasmāt dustajanasya prayatnena.

Vrhat Samhitā, 106.4

All this gives a prerogative of bringing the literary merits of the *Siddhānta Darpana* under scrutiny in a newer light, to which this work is devoted.

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Chapter II

THE PRINCIPLE OF TRUTH–GOOD–BEAUTY AND MATHEMATICS

Tryaryamā manuso devatātā tri rocanā divyadhārayanta.

Three Powers of light uphold three luminous worlds divine.

R V, v. 29.1

Among the trinities in which the Ineffable One makes itself manifest is the trinity of the Good, the True, and the Beautiful (*Satyam Shivam Sundaram*). Down the ages, the triple transformation of the Absolute has been the ultimate appropriation of all kinds of mental representations.

It is affirmed that 'beauty relates to the cognitive faculty', being the cause of knowledge, for, 'since knowledge is by assimilation, and similitude is with respect to form, beauty properly belongs to the nature of a formal cause' (St Thomas Aquinas, *Summa Theologica*. 1.5, and 1 cf. *Christian and Oriental Philosophy of Art*, A K Coomaraswamy, 1956, p.102). Our sentimental or aesthetic culture prefers instinctive expression to the formal beauty of rational art. But Plato could not have seen any difference between the mathematician thrilled by a 'beautiful equation' and the artist thrilled by his formal vision. For he asks us to stand up like men against our instinctive reaction to what is pleasant or unpleasant, and to admire in works of art, not their aesthetic surfaces but the logic or right reason of their composition. And so naturally he points out: 'I do not mean by beauty of form such beauty as that of animals or pictures, which many would suppose to be my meaning; but, says the argument,

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understand me to mean straight lines and circles, and the plane or solid figures which are formed out of them by turning-lathes and rulers and measures of angles; for these I affirm to be not only relatively beautiful, like other things. But they are eternally and absolutely beautiful, and they have peculiar pleasures, quite unlike the pleasures of scratching.' (Plato's *Philebus*, 51, cf. E F Carritt in *Philosophies of Beauty*, Oxford, 1931, pp.29–30)

Prof. G H Hardy, a mathematician of the recent times has analysed the beauty of mathematics in a penetrating and illuminating way and in welcome contrast to the vagueness that is so characteristic of most modern writings on the criteria of beauty in other kinds of art.

> A mathematician, like a painter or a poet, is a maker of patterns... The mathematician's patterns, like the painter's or the poet's, must be beautiful, the ideas, like the colours or the words, must fit together in a harmonious way. Beauty is the first test: There is no permanent place in the world for ugly mathematics. And here I must deal with a misconception which is still widespread (though probably much less so now than it was twenty years ago), what Whitehead has called the 'Literary superstition' that love of and aesthetic appreciation of mathematics is 'a monomania confined to a few eccentrics in each generation'.
>
> *A Mathematician's Apology*, CUP, reprint 1998, pp.84– 85

Prof. Hardy has admitted that it would be difficult now to find an educated man quite insensitive to the aesthetic appeal of mathematics. Even Prof. Hogben, who is out to minimise at all costs the importance of the aesthetic element in mathematics, does not venture to deny its reality and Whitehead's 'literary superstition' has been disapproved by Hardy as absurd.

Plato said: 'The better part of the soul trusts to measure and calculation,' (*Republic*, x. 602) and 'God himself is a

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geometer' (Theaetatus, 1436). He is said to have inscribed over the entrance to his school: 'Let no one ignorant of geometry enter' (Adolph Busse, (ed.) *Commentaria in Aristotelem Graeca*, XVIII, Berlin, 1900: 118). In accordance with the Pythagoreans' concept that numbers are the regulatory powers of nature and 'No art exists without analogy, yet analogy is founded in numbers; as such all art exists through numbers' (cf., 'Symmetry as a developmental principle in Nature and Art', Werner Hahn, *World Scientific* , 1998, pp.9–10). Plato propounded an 'aesthetics of number and proportion'. At the end of Plato's *Philebus* (64-e) Socrates declared: 'So now the essence of good has found shelter with the nature of beauty. For proper proportion and appropriate relation (symmetry) clearly turn into beauty and virtue everywhere.'

Bertrand Russell, in his essay 'The Study of Mathematics', has regretted that mathematicians do not read Plato, and those who read do not know mathematics and think that his views on this is a curious aberration. Exposing the beauty of mathematics he has said:

> Mathematics, rightly viewed, possesses not only truth, but supreme beauty – a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than man, which is the touch stone of the highest excellence, is to be found in mathematics as surely as in poetry.
>
> *Mysticism and Logic and Other Essays* ,
> Unwin Books, 1963, p.49

The famous aphorism of Keats – 'Beauty is truth, truth beauty and that is all' – has been interpreted by Aldous L Huxley as: 'Beauty is the Primordial Fact, and the Primordial

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Fact is Beauty, the principle of all particular beauties,' and 'Beauty is an immediate experience, and this immediate experience is identical with Beauty-as-Principle, Beauty-as-Primordial Fact' (*The Perennial Philosophy*, Fontana Books, p.146). The Primordial Fact has been elucidated, so aptly by Prof. John D Barrow, as mathematical patterns which reveal why all discussions of the universe and its contents lead so quickly and inevitably to mathematics.

> The evolution of life by a slow process of natural selection is possible only because there exist regularities in Nature. Those regularities specify the reality to which the gradual process of adaptation approaches. Whether or not living things are aware of it, they are embodiments of theories about the laws of Nature drawn from the part of Nature that they have encountered. The size and strength of a bird's wing reflect the intrinsic strength of gravity about which the bird has no theoretical understanding. ...Nature exhibits pattern, and so it obeys rules, and is subject to limits: there are things which cannot happen. Natural patterns allow us to build artificial patterns of still greater complexity. These patterns can be viewed as consequences of the natural pattern that we call 'life' interacting with other patterns. ...The inevitability of pattern in any cognisable Universe means that there can exist descriptions of all these patterns. ...In order to describe these patterns, we need a catalogue of all possible patterns. And that catalogue we call 'mathematics'. Its existence is not therefore a mystery; it is inevitable. In any universe in which order of any sort exists, and hence in any life-supporting universe, there must be pattern, and so there must be mathematics.
>
> *Impossibility*, Vintage, 1999, pp.191–92

The question of mathematical truth is a very old one. However, some very great clarifications and startling new insights have been obtained just over the past one hundred years or so. The issues are quite fundamental and they

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touch upon the very question whether our thinking processes can indeed be entirely algorithmic in nature. Taking all the issues into consideration Prof. Roger Penrose however concludes that the notion of mathematical truth goes beyond the whole concept of formalism. There is something absolute and divine about mathematical truth. This is what mathematical Platonism is about. Any particular formal system has an ad hoc and artificial quality about it. Such systems, no doubt, have very valuable roles to play in mathematical discussions but they can supply only a partial or approximate guide to truth. Real mathematical truth goes beyond mere man-made constructions (*Emperor's New Mind*, Oxford, 1999, p.146). Then he gives the message:

> Mathematical truth is not some thing that we ascertain merely by use of an algorithm. I believe, also, that our consciousness is a crucial ingredient in our comprehension of mathematical truth. We must 'see' the truth of a mathematical argument to be convinced of its validity. This 'seeing' is the very essence of consciousness. It must be present whenever we directly perceive mathematical truth. When we convince ourselves of the validity of Gödel's theorem we not only 'see' it, but by so doing we reveal the very non-algorithmic nature of the 'seeing' process itself. (Ibid., pp.540–541)
>
> Cleinias: And what are these necessities of knowledge, stranger, which are divine and not human?
>
> Athenian: Those things without some use or knowledge of which a man cannot become a God to the world nor a spirit, nor yet a hero, nor able earnestly to think and care for man.
>
> *Plato's Laws*, p.818, cf., *Mysticism and Logic and Other Essays*, Bertrand Russell, Unwin Books, 1963, p.49

If the term 'good' is taken to be a synonym for 'necessary' or 'useful', much can be said about the goodness of applied mathematics as Prof. A N Whitehead has said about 'the

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tremendous effect of mathematical knowledge on the lives of men, on their daily avocations, on the organisation of society' or as Hogben has said: 'Without a knowledge of mathematics, the grammar of size and order, we cannot plan the rational society in which there will be leisure for all and poverty for none' (cf. *A Mathematician's Apology*, G H Hardy, Cambridge, pp.136–137). But the real goodness of mathematics lies in the power of fertilizing the soul. Th e mathematics which is free from pedantry and triviality 'has permanent aesthetic value as for example the best Greek mathematics has, the mathematics which is eternal because the best of it may, like the best literature, continue to cause intense emotional satisfaction to thousands of people after thousands of years.' (Ibid., p.131)

The preceding explanation of the triad '*Satyam Shivam Sundaram*', Platonic as it were, might make the Vedic seers of antiquity turn in their graves. The metamathematics as has been envisaged by the Platonists and the Neo-Platonists was nevertheless contemplated in the Vedic exegesis. For example, the problem that appears to have attracted the attention and interest of the Vedic seers was to get on with a mathematical equation for infinity. According to tradition only the gods Indra and Visnu succeeded in solving it. And for that they have been extolled highly in Vedic literature. The earliest reference to this is found in the Rig Veda:

Umā jigyathuma parājayethe na parā jigye katarascanainoh
Indrasca Visno yadapasprdhe tham
Tredhā sahasram vi tadairayethām.

R V, VI. 69.8

Ye twin have conquered; Ye are not conquered;
Neither of the two of them hath been defeated;
Indra and Visnu, when ye contended
Ye did divide the thousand into three.

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It is generally unknown how the problem of dividing 1,000 by three could have been solved for it is not divisible. So the Vedic interpreters have explained away the whole thing as a metaphorical statement. But a passage in the *Satapatha Brāhmana* (III.3.1.13) seems clearly to belie all such speculations, saying: 'When Indra and Visnu divided a thousand into three parts, one remained in excess, and that they caused to be reproduced into three parts. Hence, even now if anyone attempts to divide a thousand by three, one remains over.' It is not only evident that the Vedic seers were aware of infinite decimal expansion but also surprising that their contemplation of infinite number was so identical with that of the most modern mathematicians. In this context the following extract from Roger Penrose's *The Emperor's New Mind* may be compared.

> It might be felt that it is impossible to contemplate an entire infinite expansion, but this is not so. A simple example where one clearly can contemplate the entire sequence is 1/3 = 0.3333333333333333...... where the dots indicate to us that the succession of 3s carries on indefinitely. To contemplate this expansion, all we need to know is that the expansion does indeed continue in the same way indefinitely with 3s. (p.107)

Another famous example of Vedantic metamathematics is such as:

Aum purnamadah purnamidam
purnāt purnamudicyate
Purnasya purnamādāya
Purnamevāvasisyate.

Brhadāranyaka, 5.1.1

In mathematical equation this can be stated as: The Absolute ± the Absolute = The Absolute.

In order to understand the significance of the above

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statement, the beautiful and powerful theory of infinite numbers put forward by the highly original Russian – German mathematician George Cantor strangely complements. According to the theory, the total number of fractions, the total number of integers, and the total number of natural numbers are all the same infinite number denoted by '$\aleph_0$' (Aleph Nought).

As a common phenomenon of all civilisations, it is found that the mathematical knowledge developed step by step from counting of fingers (*Sa bhumim visvato vrtwatyatisthat dasangulam*, Rig Veda, X.90.1) according to the dictates of the material needs of the social life. But it is noteworthy that the Vedic people went much farther than what was warranted by such needs and cultivated an interest for the subject fully in keeping with the fact that mathematics is inherent in Nature itself. That is why we find them preoccupied with large numbers, problems of irrational quantities and elementary surds indeterminate problems and equations, arithmetical and geometrical series, and the like. Of course, designing of sacrificial altars, linguistic intricacies of metre and rhyme, and commercial accounting enhanced the development of mathematics, but its greatest urge came from the realisation of the synchronousness of earthly events with the motions of celestial bodies. In India, as elsewhere, higher mathematics developed as a sequel to astronomical advancement; and it is no wonder that the bulk of post-Vedic mathematics has been found only in association with the *siddhantas*.

The Vedic people were fascinated by mathematical ideas not because they were intrigued by them but for the playful beauty of mathematics in life itself. They had understood that it was not the season but the number 'six' and not the month but the number twelve that was playing with their lives in a manner of eternal recurrence. Therefore, they had preferred using symbolic numbers extensively in the hymns as:

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> The twelve-spoked wheel of the true revolves round the heavens, and never to decay. Seven hundred and twenty children in pairs, Agni, abide in it. They have termed the five-footed, twelve-formed parent, Purishin, when in the further hemisphere of the sky and others have termed him Arpita, when in the hither, shining in his seven-wheeled car, each wheel having six spokes.
>
> Rg Veda, 1.164, 11–12

This type of Vedic tradition in which mathematics is treated as an inevitable part of life gave rise to a kind of prosody that found its way cutting through the rocks of mathematical jargon but all the while murmuring like a rivulet. That, the supernal beauty of mathematical truth is not as such averse to the polish of poetic expression, was proved by Āryabhatta (AD 467) who adopted, for the first time, a system of numeration by substituting poetic words such as 'sky' for zero, 'earth' or 'moon' for 'one', 'eyes' for two, etc. Fabrication of word-numerals may be traced back to the Rig Veda (VII. 103.1) but it is noteworthy that Āryabhatta has named his treatise on astronomy as *Geetikā Pāda* or 'lyrical lines'.

Mahāvirāchārya, (AD 815), in his famous *Ganita Sāra Samgraha*, has acknowledged that the beauty of mathematics, as an attribute of art, excels the aesthetic value of all other branches of knowledge such as:

> *Kāmasāstre' rthasāstre ca gandharve nātakepi vā*
> *Supasāstre tathā vaidye vāstuvidyādivastusu*
> *Chando' lankārakāvyesu tarkavyākaranādisu*
> *Kalāgunesu sarvesu prastutam ganitaparam.*
>
> Cf. *Bhāratiya Jyotisara Itihas*, B Mohapatra, OSA, p.192

Bhaskara (AD 1114), while naming his book on arithmetic, has said: *Samksiptāksara komala'mala padairlālityalilavatim* (*Lilavati*-1) (It is a composition of soft and clear words of beauty, frolicsome like a girl, that is why, 'Lilavati').

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When we ultimately come across the last *Siddhānta* ever written in India i.e., the *Siddhānta Darpana* of Samanta Chandrasekhar (1892), the last flicker of the same Vedic luminosity is seen dazzling with its catastrophic vigour. The author has designated it as *Skandhasāra prabandha* (S D, 24/158). *Prabandha* is the synonym for *kāvya* or *sargabandha* meaning a poetical work and *skandhasāra* is the best part of astronomy, i.e., mathematics. The epithets adduced by the author in different places of the work, such as '*Padyairhrdyatarai rabadya rahitai sadyo'vi vedyarthakai*' (S D 1/23) (A flawless and heartfelt poem whose meaning is grasped at once) and '*Akarkasa vakya cakram*' '*Grahyam mudopakaranartha*' (S D, 7/1) (A cycle of sweet-sounding sentences acceptable for pleasure's sake) etc., speak of his poetic disposition.

Siddhantas do describe beauty and truth, but of whom? The critics and commentators of the *Siddhānta* have invariably been myopic about the characteristics of a *Siddhānta* and resultantly forgotten the likely existence of an all-powerful protagonist within its epic structure. A *Siddhānta* is not only a treatise on astronomy to be deduced only in the language of mathematics and physical science. It contains an Omnipresent, omniscient and omnipotent Hero who has thrown himself out into forms in a triune truth-good-beauty or truth-consciousness-beatitude, whatever it may be. As per the aphorism on rasa, He happens to be the *ālambana vibhāva* (the principal determinant towards which an emotion is manifested) and Nature, as His counterpart acts as the *Uddipana Vibhāva* (environmental determinant which excites the emotion). As Ganesh Daivajna, in his *Jātakālankār*, has said:

Sadbhāva kalitam padārthalalitam yogāngalilārcitam
Srimadbhāgabatam sukāsyagalitam yatsridharasvaāminā
Suvyaktamkriyate Ganesakavinā gāthoktitadjātakam

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Vrttasragdhāraya janādi suphalam jyotirbidāmjivanam
yatpurvam paramam sukāsyagalitam sadjātam fakkikā
Rupam gudhatamam tadeva visadam kurve Ganesosmyaham.

Cf. *Bhāratiya Jyotisara Itihas*, pp.253–254

I, Ganesh Daivajna, the poet, am going to describe the beauty of the horoscope of Lord Krishna, on the basis of the legends available in *Srimad Bhagavatam* which had been poured out from the mouth of Sukamuni and critically analysed by Sridhara Swami, in Sragdhāra metre.

So also has said Samanta Chandrasekhar:

Trtyādi pralayāntakālakālanāt pretesituhsāsanāt
Niladravyacayādhikāsitarucah kālesukhā dānatah
Nilasyā calanāyakasya siraso' lankārabhābādsvatah
Saproktah Kilakālakāla iti yah krsnāya tasmai namah.

S D, 24/153

I pray to Lord Krsna who measures the alpha and omega of time; subdues the Lord of the deceased, the blackest one, Yama; ever blissful; and as the crest jewel of the hero of the mount Nila (Blue) who boasts of the name Kālakāla or the death of death itself, I pray to Him.

The foremost objective in writing these *Siddhantas* is not to prepare an almanac but to know the triple status of the Supermind is obvious. Again and again he has said:

Hladinyāhlāda simārbuda madanaruci sandhinisandhitātma
Sambitsabātadhāmā nigamagana sirastu satyāsatya prabhava
Sesāsesānga sadmasura tarutalabhāt Kalpita premarupah
Srikrisna premabhaktim vitaratuhrdinah satcidānanda rupa.

S D, 23/50

This cryptic verse suggests that there is a principle superior to the mind which satisfies the conditions in which mind

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fails. It is *Sat-Chit-Ananda* itself that is this principle of Trinity, but *satcidananda* not resting in its pure infinite invariable consciousness, but proceeding out of this primal poise, or rather upon it as a base and in it as a continent, into a movement which is its form of energy i.e. *Hl ādini-Sandhini-Sambid* and instrument of cosmic creation. Consciousness and force are the twin essential aspects of the pure power of existence, e.g. *Sat*. Knowledge and will must therefore be the form that power takes in creating a world of relations in the extension of time and space, i.e. *suratarutalabhātkalpita* (thought under the divine *Kalpataru*). The supermind then is being moved out into a determinative self-knowledge which perceives certain truths of itself and wills to realise them in a temporal and spatial extension of its own timeless and spaceless existence. And the poet obviously laments:

Yasyeccāme nija bhajana to dura mutsārya buddhim
Daivadhināmganita vipanau pātayatyātatāyām
Samkhyātitāmugata patitoddhāra kārunya sindhuh
Sasyaccetah sarana caranah sindhujā prānabandhuh.

S D, 15/71

It is He, the beloved husband of the daughter of the ocean, who has thrown my intellect out of oblation, into the emporium of mathematics. May He, the ocean of mercy for the downtrodden, provide shelter to me so that I do not lose my way in this hard pursuit.

According to the pan-Indian conception of *kāvya* i.e., *Dharmārtha Kāmamoksyānām vaicaksyanya Kalāsuca, Karotikirti pritimca sadhukāvya nisevanam* (Kāvyalankar – Bhamaha) it postulates the *Siddhantas* that fulfil the four prime purposes of life, so say the authors, such as:

'*Yasascaturbarga phalapradam srtam pavitrametat pathaniyamevatat*' (*S D*, 1/19). Those are namely *Dharma* (religion), *Artha*

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(wealth), *Kama* (desire), and *Moksya* (salvation). Thus, the combination of mathematics and theology, which began with the Vedas, characterised the religious philosophy in India in the ancient and middle ages and in the modern times down to Samanta Chandrasekhar. In the *Vedanga Jyotiṣa* as well as in the works of Āryabhatta, Bhaskara, Satānanda, Sripati, and Chandrasekara there is an intimate blending of religion and reasoning of mo ral aspiration with logical admiration of what is timeless, which comes from the Vedas, and distinguishes the intellectualised theology of India from the more straightforward empiricism of Europe.

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Chapter III

THE POET'S EYE: NATURE AND ASTRONOMY

Poet's eye, in a fine frenzy rolling
Doth glance from heaven to earth, from earth to heaven
...the poet's pen... gives to airy nothing
A local habitation and a name.

Shakespeare, *A Midsummer Night's Dream*, V. I. 1–28

Mahidyāvāprthivi ihajyesthe rcā bhavatām sucayadvirarkaih
Yat si varisthe Vrhati viminvan ruvadhoksya papra thanebhirevaih.
Devi deveviryajate yajatrai – raminati tasthatu ruksyamāne
Rtavari aduhādevaputre yajñasyanetri sucayadvirarkaih.
Sa it syapā bhuvanesvasa ya ime dyāvāprthivi jajāna
Urvigavire rajansisumeke avamse dhirah shacyasamairat.

R V, IV. 56, 1–3

Vast and most excellent Heaven and Earth, be present with splendour at this sacrifice, attracted by sanctifying hymns, since that the showerer sounds everywhere with his heralds, the rapid winds, passing through the two spacious and mighty regions. May the divine, adorable, benevolent, fertilising, truthful, unoppressive Heaven and Earth, the leaders of sacrifice, whose sons are the gods, be present with the adorable gods being attracted by the hymns. Verily he was the doer of a good work in the regions, who generated these two, Heaven and Earth, and firm of purpose, gave an impulse by his deed to the two vast, immovable, beautiful, unsupported worlds.

Nature is precisely what the Veda calls '*dyāvā-prthivi*' or

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Heaven-Earth, born in eternal conjugality as a result of which the birth of the gods takes place. But of whom they are born? The Veda identifies it as Brahmā. The word Brahmā is derived from the Sanskrit root *bṛh*, meaning to grow, and thus suggests a reality which is dynamic and alive. The dynamic principle by which infinite Brahmā is manifested as visible and realised Nature is called *ṛta* which means 'the course of all things', the order or law of Nature. This law develops the triune principle of 'existence, consciousness-bliss' out of their indivisible unity. It differentiates them, but it does not divide. It establishes a Trinity (*tritah*) and the trinity of Bhārata's dramaturgy (*Vibhāva, Anubhāva, Sañcāribhāva*) is connotative of the same. Sri Aurobindo has defined it as follows:

> A consciousness-force, everywhere inherent in Existence, acting even when concealed, is the creator of the worlds, the occult secret of Nature... The first aspect of cosmic existence is an Infinite which is to our perception an indeterminate, if not indeterminable. In this Infinite, the Universe itself, whether in its aspect of Energy or its aspect of structure, appears as an indeterminate determination, a 'boundless finite', paradoxical but necessary expressions which would seem to indicate that we are face to face with a suprarational mystery as the base of things, in that universe arise – from where? – a vast number and variety of general and particular determinates which do not appear to be warranted by anything perceptible in the nature of the Infinite, but seem to be imposed, or it may be self-imposed, upon it. We give to the Energy which produce them the name of Nature, but the word conveys no meaning unless it is that the nature of things is what it is by virtue of a force which arranges them according to an inherent Truth in them; but the nature of that Truth itself, the reason why these determinants are what they are is nowhere visible. It has been possible indeed for human Science to detect the process or many processes of material

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> things, but this knowledge does not throw any light on the major question; we do not know even the rationale of the original cosmic processes, for the results do not present themselves as their necessary but only their pragmatic and actual consequence. In the end we do not know how these determinates came into or out of the original Indeterminate or Indeterminable on which they stand forth as on a blank and flat background in the riddle of their ordered occurrence. At the origin of things we are faced with an Infinite containing a mass of unexplained finites, an Indivisible full of endless divisions, an Immutable teeming with mutations and differentiae. A cosmic paradox is the beginning of all things, a paradox without any key to its significance.
>
> R F ed., *The Life Divine*, 1986, pp.295–97

The wandering for the key to the paradox has since not stopped either. Right from the Vedic age down to the ultramodern age of astrophysics, it is going on but to no avail, because our discriminating intellect does not have that transcendental vision, *drsti* the power so highly valued by the ancient sages, the power which made a man a *rsi* or *kavi* and no longer a mere wanderer. To the ordinary vision the triune breaks into myriad manifestations as happenings of Nature and the vision is lost in its multiplicity. The ordinary vision cannot comprehend how the trinity multiplied itself into 3333 gods (*Trini sata tri sahasrānijagnim trimsasca devā nava cāsaparyan*) (R V III 9.9/x.52.6). Though the intellect can formulate this permutation and combination mathematically, it cannot conceptualise why at all Nature operates like this, and who or what makes Her to operate. The character of the Master Maker of all these phenomena is necessarily difficult to seize. Even the Vedas and the Upanisads only shadow them out by figures, hints, and symbols. Yet it is necessary to attempt some account of their principles and practical effect so far as they can be grasped

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by the mind that stands on the border of the two hemispheres of the paradox. Vedic astronomy just does that which is why it has earned the name 'The eyes of the Veda' (*Siddhānta Siromani* 1.10, *Siddhānta Darpana* 1.15, etc.). Vedic astronomy is not a science in the limited sense of the term. It is gnosis or *Vijñāna*, direct and divine knowledge as opposed to indirect and human knowledge.

There is the Vedic image in which the sun represents the gnosis, and the earth, air, and sky (*Bhuh*, *Bhuvah*, *Svah*) represent the body, life, and mind of man as well as of the universe. The mental power cannot surpass the domain of the Sun whose rays surround the three worlds. The mind would perceive things in the light according to the ability of his organ of vision. But the Gnostic power lies with the Sun which sees with its self-luminous blaze, the all-pervading truth of the triple world and everything that comes within its orb. It sees not by reflection in any organ of vision, but by itself, by the gnosis. That is why the Sun is described as the eye of the universe. The mental reason endeavours to shed its ignorance to reach the truth, but the gnosis possesses the immediate vision of truth, without inference, deduction, induction, analogy, and as directly as the physical vision sees the objects, so the gnosis sees and knows. The physical vision depends upon senses to arrive at the truth and shows truth in the light of the appearances. The gnosis identifies with the truth and shows the appearances in the light of the truth. To the mind seeing is believing. To the gnosis seeing is ad infinitum, there is no gap for doubt or belief. It does not twinkle while on looking the universal dramatic persona. Later on this Vedic conception had been further articulated in the Upanisads through which the philosophy of *Sāmkhya* emerged of theorising *Dyāvā -Prthivi* as *Purusa-Prakrti* and the gnosis as witness (*saksi*). The word *sāmkhya* is derived from the original word, '*sāmkhyā*' (intellect) which again gives rise to the word, *Samkhyābān*, a

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synonym of the word 'poet'. Almost all the *Siddhantas* have admitted adherence to the philosophy of *sāmkhya* . (Vide *Siddhānta Siromani*, *Golādhyāya*, *Bhuvanakosa*, 1; *Siddhānta Darpana*, 1/21; *Surya Siddhānta*, *Bhugolādhyāya*, 13)

Cetanasyāpyavyaktasya Jagatkartrtvamuktam purusa Sannidhāna matrehā-
Acetanāpi prakrtih pragādha matmopakanthe sakalam sanoti
Acetanam samcalativa loham svayamyathā bhrāmaka sannidhāne
Vatsavibrdhinimittam ksirasyayathā prabrttirajñasya
Purusavimoksanimittam pravartate tadvadavyaktam,
Mulaprakrtiravikrtirmahadadyah prakrtibikrtayah sapta
Sodashakastu vikāro na prakrtirnavikrtih purusah
'Purusastu puskarapalāsavat nirlepah' – Sāmkhya – 1.

Cf. Nrsimha Daivajña's commentary on the
Siddhānta Siromani, Varanasi, 1998, p.343

As per this *Sāmkhya* theory of creation which has been accepted by the *Siddhānta* writers, causation is automatic and continuous. The two ultimate entities are Nature (*prakrti*) and Spirit (*purusa*). The whole of the physical universe emanates from these two. Nature has within it a sort of inherent teleology that the combination of its triple attributes (*Sattva*, *Raja*, *Tama*) should serve the spirit in providing him with experience and ultimately detach him from the bondage of Nature itself through the dissolution of individual minds or intellects leaving him supremely alone in his nature as pure intelligence or illumination. This state of the spirit is *nirlepa* or 'non-attachment', the Brahmā. The prolegomena of Indian dramaturgy and aesthetics *Nirvikāratmake citte bhāva prathama vikriyā* (mental state, i.e., bhava is the first deformity of the nescient mind) (*Sāhitya Darpana*, III/93) is in this way related to the *Sāmkhya* theory of creation and terms the aesthetic experience as *Brahmānandasahodara* or womb-mate of the Absolute Bliss.

As the classical idea of nature paved its way out in the

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aesthetic speculations, it took on certain significant developments. The idea of the universality and uniformity of Nature appeared now strongly reinforced by geometric standards of clear reason and by astronomical concepts of a mechanically ordered universe. Some of the most agile men of letters were able to reconcile the new scientism and rationality with the older principle of authority or reverence for the ancient models. The literary rules were said not to supplant but to methodise nature. For instance, the famous definition of the aesthetic experience given by Viswanāth may be compared:

> Rasa is tasted by the qualified persons by virtue of the emergence of *sattva*. It is made up of a full Intelligence, Beatitude, and Self-luminosity. It is void of contact with any other knowable thing, womb-mate of the Absolute Bliss. It is animated by an astonishment of extraordinary nature. It is stated as if it were our very being, in indivisibility.
>
> *Sāhitya Darpana*, III 2/3

Mimesis or the concept of 'imitation', which becomes the central argument in later passages of Plato's *Republic*, postulates everything that comes in opposition to Nature as unjust. Certain poems, he observes, simply tell what happened, others imitate what happened. The four ascending phases of knowledge, according to Plato, are: *eikasia* or sensory imagination, *pistis* or faithful apprehension, *dianoi a* or discursive understanding of mathematical or geometric figures, and at the top *noesis* or intuitive knowledge of permanent beings, the forms or ideas. Plato believes that even a bed made by a carpenter is an imitation of the divine bed created by God and the bed described by a poet is twice much far from reality.

Aristotle considers the mimetic relation between 'practical art' and Nature in more scientific contexts. His

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famous statements like 'Art imitates nature', 'Art finishes the job when nature fails or imitates the missing parts' do not occur in the 'Poetics' but in the 'Meteorology' (vi. 3) and 'Physics'. (11.8) (*Literary Criticism: A short History*, Wimsatt, Brooks, Oxford, IBH, 1970, pp.11–13, 26)

Drawing a sharp contrast between classic and romantic treatment of Nature in poetry, the Roman classicist Longinus, in his essay *Peri Hupsous* (The Sublime), commends the idea of physical grandeur as the counterpart of the psychic. The sublime state of soul is to be measured by the magnitude of the external objects mentioned in a piece of literature, as he says:

> Nature has appointed us men to be no base or ignoble animals, but when she ushers us into the vast universe as into some great assembly, to be as it were spectators of the mighty whole and the keenest aspirants for honour, forthwith she implants in our souls the unconquerable love of whatever is elevated and more divine than we. Wherefore, not even the entire universe supplies for the thought and contemplation within the reach of the human mind, but our imaginations often pass beyond the bounds of space, and if we survey our life on every side we see how much more it everywhere abounds in what is striking, and great, and beautiful, we shall soon discern the purpose of our birth. This is why, by a sort of natural impulse, we admire not the small streams useful and pellucid though they be, but the Nile, the Danube, or the Rhine and still more the Ocean. Nor do we view the tiny flame of our own kindling (guarded in lasting purity as its light ever is) with greater awe than the celestial fires though they are often shrouded in darkness, nor do we deem it a greater marvel than the craters of Etna, whose eruptions throw up stones from its depths and great masses of rock, and at times pour forth rivers of pure and unmixed subterranean fire.
>
> Cf. *The Greek View of Poetry*, E Sikes, p.236

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Greek influence upon the development of astronomical *Siddhantas* has been referred to for a long time. Garga and Varāhamihira have honourably mentioned the proficiencies of the Yavanas (Greeks) in astronomy. Varāhamihira, in his *Bṛhajjātaka*, has freely used many Greek terms applied in astronomical works. The names of the twelve zodiac signs have been transliterated into Sanskrit. Many Greek words, like *kendra*, *apoklima*, *liptā*, *hora*, have passed unchanged into the Indian astronomical works. Of the five *Siddhantas* summarised by Varāhamihira in the *Pañcasiddhantika*, the *Romaka* and the *Paulisa Siddhānta*, as their very names purport, have long been taken to contain elements of Greco-Alexandrian astronomy in spite of their Indianisation. The *Romaka* used the metonic cycle, and the *Paulisa* used a period different from the *yuga* of later Hindu astronomers. One of them computes *Ahargana* (Number of civil days that elapsed from the beginning of an epoch) for the meridian of Yavanapura and Ujjain. According to these findings Thibaut has said:

> That the similarities observed between the Greek and the Hindu systems are due to a transfer of the elements of the former to India, will at present be hardly called into doubt, and it certainly appears highly probable that the *Paulisa* and *Romaka Siddhantas* were the earliest Sanskrit works in which the new knowledge imported from the West was embodied.
>
> *Introduction to Pañcasiddhantika* by G Thibaut, Chowkhamba, 1997, p.LI

But hardly anything is mentioned about the Indian influence upon the development of Greco-Alexandrian astronomy because of our inability to explore the interiority of the distant past. Prof. H G Rawlinson, in contradiction with the prevailing views, had properly adjudged: 'It is more

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likely that Pythagoras was influenced by India than by Egypt. Almost all the theories, religious, philosophical and mathematical taught by the Pythagoreans were known in India in the sixth century BC' (*Legacy of India*, 1937, p.5). Quoting Herodotus (iv, 44), S Radhakrishnan has said that the first Greek book about India was perhaps written by Scylax, a Greek sea captain, whom Darius commissioned to explore the course of the Indus about 510 BC (*Eastern Religions and Western Thought*, p.134). But an astounding evidence has now been exposed in *The Schemata of the Stars – Byzantine Astronomy from AD 1300*, a literal translation of the original Greek work by E A Paschos and P Sotiroudis. How do the introductory passages of this thirteenth-century treatise on Greco-Byzantine Astronomy unequivocally reverberate with the Vedic conception of *Dyāvā-Pṛthivi* can be recognised from these lines:

> The (Celestial) body is divided into two (entities), simple and composite, as is the case with the four elements, simple and composite; each of them is thus called simple element. It became evident from what we know and comprehend that the sky is circular. On the other hand, the elements are four: fire, air, water and earth, if something is composite then it is none of these.
>
> The entities beyond the elements are classified into two groups; one group where the mixing is not perfect, so that when mixing takes place the composition does not survive (for a long time); examples are air and clouds and thunderbolts. The other group is the one in which mixing is perfect, when mixing takes place, the composition lasts for a long time. There are three such things; first the one which is produced and cannot develop any further, as is the case with metals; second the composed (substance) has the capacity for growth, as is the case with plants; and third, the one which has the capacity for both growth and movement, as is the case with animals. These three are

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> called children of three structures, and this because the four elements are called their mother. On the other hand, the sphere and the stars are known as their father.
>
> p.27

The Greeks, like the ancient Indians, believed the heavenly bodies as gods, and each closely controlled by its own god or goddess. God, the Aristotelian Unmoved Mover, caused the rotation of the Primum Mobile, which, in turn communicated its motion to the spheres of the fixed stars, and so on downwards to the sphere of the moon, they believed.

The eyes of the Vedic seers, on looking at the splendours of nature, was no doubt fabulously poetic, but nevertheless astronomic also. Their vision was not bound by a single paradox, i.e. the Heaven-Earth singularity. Innumerable natural phenomena, which seemed to have an inherent calculability, had a bearing on their thought and they were promoted by Nature itself to make out its mathematical functioning, as if it was the only beauty for magical functioning, for their mind's eye. The endeavour to comprehend the world and the universe landed them in stricter and more fastidious premise and gave rise to a special branch of classic literature namely the *Siddhantas*. The compendium of astronomy enlarged day by day, including in its contents a series of natural phenomena like the solar eclipse, the lunar eclipse, the waxing and waning of the moon, motion of the heavenly bodies, appearance of the constellations, signs of the zodiac, the solstices and equinoxes, heliacal risings and settings, days and months, the year, epochs, galaxy, time, space, motion and state of rest, and all sorts of entailments of these for methodising nature.

The mediaeval Siddhantic cosmos, being more austere

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than that of the Vedic, was shorn of some elements of poetic fancy that mythopoetics had preserved and elaborated to the end, in the Puranas. Thus the Vedic Purusa turned out to be the *naksatra purusa* in *Brhat Samhitā* (LVIII. 105), *Brhajjātaka* (i.4.), *Matsya Purana* (Ch. LIV) and *Srimad Bhagavatam* (5.21). In order to fathom the vastness and mystery of Nature, the Vedic seers had dedicated their eyes and ears. They had used them in search of truth and in such manner as astronomers could use their eyes in the age of naked-eye observation or pre-telescopic era. In the Rig Veda, Bharadwaja says:

> *Dhruvamjyotirnihitam drsaye kam manojavistham patayansuyantāh*
> *Visvedevahsamanasah saketā ekam kratumāmi viyanti sadhu.*
> *Vime karnā patayato vi caksurvi idam jyotirhrdaya aahitam yat*
> *Vime manascarati duraādhih kim svid vaskami kimunu manisye.*
>
> R V IV, 9.5–6

> A steady light swifter than thought, stationed among moving beings to show (the way) to happiness – all the gods being of one mind, and of like wisdom, proceed respectfully to the presence of the one (chief) agent, Vaisvānara. Mine ears are turned (to hear him), mine eyes (to behold him); the light that is placed in the heart (seeks to know him); my mind, the receptacle of distant (objects) hastens (towards him), what shall I declare him? How shall I comprehend him?

Celebrity of a *Siddhānta* depends upon its observed truthfulness or '*drk siddhatā*' (*S S Spastādhikār*, 1.1/ *S D*, 1.8, etc.) for which astronomer-poets exercise their eyes in all-out effort of scrutinising the Nature. The Vedic seer had contended to imitate the eye of the universe, i.e., the Sun or Vaisvānara who was measuring the summits of the universe by his light:

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Vaisvānarasya vimitani caksasā sānuni divo amrtasya ketunām Pasyedu visva bhuvanādhi murdhani daya iva ruruhuh sapta jisruhah.

R V, VI, 7.6

So did the astronomer-poets of the *Siddhantas*. It is well known how Samanta Chandrasekhar was put to test by the commissioner of Orissa and was able to measure the height of a distant hill by glance. In his *Siddhānta Darpana* he has presented (*S D*, 19/70–85) rules for measuring the height of hills, trees, and clouds. A poet's eye does not necessarily glance vaguely. It measures while it glances, as a poet's way of knowledge.

In the Vedic age, there was a period when idea about the world and the cosmology underwent a crucial transformation from that of 'mythos' to 'physis', or from mythological descriptions regarding the creation of the world and the order of nature to a natural description based on the process of reasoning. The *Nāsadiya sukta* (R V 129) reflects the transition thus:

Nāsad-āsin no, sad-āsit tadānim
Nāsid rajo no vyomā paro yat.
Kim-ā varivah kuhaka sya sarmann
Ambhah kim asid gahanam gaviram.
na mrtyur āsid amrtam na tarhi
na rātryā ahna āsit praketah
ānid avātam-svadhayā tad ekam
tasmād-dhānyan-naparah kimcanāsa.
tama ā sit tamasā gudham agre
aparaketam salilam sarvam ā idam,
tucchyenābhu apihitamyad āsit
tapasas tan mahinājāyataikam.
Kāma stad agre sam avartatādhi
manaso retah prathamam yad āsit
sato bandhum asati nir-avindan
hrdipratisya kavayo manisā.

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tirascino vitato rasmir esām
adhah svid asid upari svid āsit
retodha āsan mahimāna āsan
svadhā avastāt prayātih parastāt
Ko addhā veda ka iha pra vocat
Kuta ājāta kuta iyam visrsti
arvāg devā asya visarjanena
atha ko veda yata ababhuva.
iyam visrstir yata ābabhuva
yadi vā dadhe yadi vā na
yo asyādhyaksah parame vyoman
so anga veda, yadi vā na veda.

Then existence was not, nor non -existence, the mid -world was not, nor the ether nor what is beyond. What covered all? Where was it? In whose refuge? What was that ocean dense and deep? Death was not, nor immortality, nor the knowledge of day and night. That one lived without breath by his self-law, there was nothing else nor aught beyond it. In the beginning darkness was hidden by darkness; all this was an ocean of inconscience when universal being was concealed by fragmentation; then by the greatness of its energy That One is born. That moved at first as desire within, which was the primal seed of mind. The seers (poets) of truth discovered the building of being in non-being by will in the heart and by the thought; their ray was extended horizontally, but what was there below? What was there above? There were Casters of the seed, there were Greatnesses; there was self-law below, there was will above. Who really knows? Who in this world may declare it? Where was this creation, whence was it engendered? The gods were subsequent to the creation, so who knows whence it arose? He from whom this Creation arose, he may uphold it, or he may not, no one else can; He who is its superintendent in the highest heaven, He assuredly knows, or if He knows not, no one else does (tr. Aurobindo).

This new form of thinking which asked questions relating to the ultimate truth and the being that lies hidden behind

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mere appearance and a changing nature, established the 'logos' as the principle of rational thought. In the idea of 'logos' as developed in Vedic philosophy the role of mathematical thinking was gradually emphasised since the mathematical method of reasoning overcomes the approximations of discourse in ordinary language and due to its ability to serve as a model. The ideal objects of mathematics make it possible to relate, through rigorous logical reasoning, the one and the many, the identical and the varied, by referring one to other elements of geometrica l figures. The 'logos' is, at the same time, and for this very reason, a claim of universality, whose idea was born with it (*Universality of Science*, Michel Paty, cf. *Situating the History of Science*, OUP, 1999, pp.306–307). Due to this universality, strikingly similar cosmogonic records are found in different ancient civilisations. A comparison may be drawn from the extracts:

(a) When on high the heaven had not been named, firm ground below had not been called by name, Naught but primordial Apsu, their beg etter, (And) Mummu Tiamat, She who bore them all Their waters co-mingling as a single body No reed hut had been matted.

No marshland had appeared,
When no gods whatever had been brought into being
Uncalled by name, their destinies undetermined
Then it was that the Gods were formed within them.

The divine brothers banded together
They disturbed Tiamat as they surged back and forth
Yea, they troubled the mood of Tiamat
By their hilarity in the Abode of Heaven.

Enuma Elish, Tablet, I, cf. *The Origins of Civilisation*,
William H McNeill and Jean W Sedlar (eds.)

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The epic *Enuma Elish* so-called from its first words ('When on high') is our principal source of knowledge about Mesopotamian cosmology. It is believed to be composed during the period when the rulers of Ba bylon first acquired hegemony over the entire Mesopotamia under the first dynasty of Babylon (1894–1595 BC), the Dynasty of Hammurabi.

(b) The Gods who came into being as Ptah
Ptah who is upon the great throne...
Ptah-Nun, the father who (begot) Atum,
Ptah-Naunet, the mother who bore Atum,
Ptah the great, that is, the heart
and tongue of the Ennead;
(Ptah)... who gave birth to the Gods...
There came into being as the heart and there came
into being as the tongue in the form of Atum.
The mighty great one is Ptah, who
transmitted (life to all gods) as well as
(to) their Ka's, through his heart
by which Horus became Ptah, and
through this tongue by which
Thoth became Ptah.

Memphis Inscription
believed to be written during the reign of
King Menes of Egypt 3000 BC, cf. Ibid.

In India, the same Vedic cosmogony has been retained by the *Siddhantas* throughout the ages. And the *Siddhānta Darpana*, even though composed in the Indo-British cross-cultural setting of the nineteenth century, has remained unaffected by the massive transfer of European knowledge, as if with a Needhamian stance. In the eighteenth chapter of the *Siddhānta Darpana* (*Bhugola Vivaranam*) we come across the cosmogony which has been quoted from the *Surya Siddhānta* (*Bhugolādhyāya*, Sl. 11–30) by the author. The

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intention of borrowing the entire cosmogonic concept from the *Surya Siddhānta* which originally belongs to the period c AD 400, is not apparent but discernibly implicit. The texture of the *Surya Siddhānta* bears the consignment of the Vedic Sun-god as its propagator and it purports to the Vedic configuration of the cosmos. Therefore, the author of the *Siddhānta Darpana* believed the cosmogony of the *Surya Siddhānta* to be, as it were, irrefutable. The horoscope of the Universe, as the *Surya Siddhānta* depicts it, is based on the *Nāsadiya Sukta* of the Rig Veda (X.129), the *Purusa Sukta* of the Rg Veda (X.90) and the *Hiranyagarbha Sukta* of the Rg Veda (X.121). But the significance of the siddhantic cosmogony lies in alluding a mytheme to the Vedic concept of creation, as the primogenitary character 'Maya, the Asura' is held to be:

'When but little of the Krta age was left, a great Asura named Maya became desirous of knowing the mysterious, supreme, pure and exalted science – the chief *Vedanga* – in its entirety: the cause namely, of the motion of the heavenly bodies.

He performed in propitiation of the Sun very severe religious austerities. Gratified by these austerities and rendered propitious, the sun himself delivered unto that Maya, who besought a boon, the system of the planets.

The blessed sun said: 'Your intent is known to me and I am gratified by your austerities. I will give you the science on which time is founded, the ground system of the planets. No one is able to endure my brilliancy for communication. I have no leisure. This person, who is a part of me, shall relate to you the whole. Go therefore to the city of Romaka where you reside. There, undergoing incarnation as a barbarian, owing to a curse of Brahmā, I will impart to you this science.' (The *Surya Siddhānta Madhyamādhikar*, Sl. 2–7)

Whitney, the translator of the *Surya Siddhānta* thinks the last verse – '*Tasmāt Tvam Sva puri gaccha tatra jñānam*

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dadāmite, Romake nagare brahmāsapa mlecchāvataradhrk' is an interpolation, but it is found in many of the manuscripts. (*Hindu Astronomy*, G R Kaye, Cosmo, 1981, p.108)

Almost all scholars of modern astronomy have ignored this mytheme as a fantastic, absurd imagination of the ancients and as a result have failed to understand the inherited response pattern of the Indian race. A myth arises wherever it becomes dangerous or impossible to speak plainly about certain social or religious matters, or affective relations, and yet there is a desire to preserve these or else it is impossible to destroy them. The 'Maya-myth' which has been invariably inherited by the *Siddhantas*, holds the archetypal key to the threshold of Indian astronomy.

Drawing on the findings of Sylvanus G Morlley and George W Brainerd in *The Ancient Maya* (Stanford University Press, 1956) and of Anthony F Aveni in *Native American Astronomy* (University of Texas Press, 1972) Graham Clark says:

> An astounding instance of the preoccupation of people on the verge of literate civilisation with astronomy is provided by the Maya people of Mesoamerica between the fourth and the sixteenth centuries AD. Although still practising a Stone Age technology, these people had developed a complex society focussed on elaborate ceremonial centres. The prime purpose of the astronomer-priests who officiated at these centres was to ensure the continuity of time and regulate the principal activities of their society. To this end they devised elaborate calendars designed to ensure that the proper ceremonies were performed at the correct times. Knowledge of the astronomy that underlie them has come down to us largely through the codices or hieroglyphic manuscripts now preserved in European centres and originally made of *Ficus catonifolia* bark reduced to a pulp and held together by a natural gum. Maya astronomy was based on the systematic observation of such things as the waxing and waning of the moon as well as

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> eclipses and the synodical revolution of the p lanet Venus. Lines of sight were taken through key points on ceremonial structures extending to distant features of the landscape, as well as from ones especially designed for the purpose. Although deploying only primitive means, the Maya attained a high degree of accuracy as a result of sustained observation.
>
> *Space, Time and Man: A Prehistorian's View*, Cambridge UP, 1992, pp.50–51

Who are these Maya people? They are 'one of an Indian people of central America and southern Mexico who developed a remarkable civilisation.' (*Chambers Twentieth Century Dictionary*, 1972)

As to the ancestry of the American people, *The Great World Encyclopaedia* (Galley Press, 1984) explains: 'The people of North America are descended from three groups: Europeans, African Negroes, and American Indians. The American Indians were the original settlers; their ancestors arrived from Asia about 20,000 years ago.' 'The ancestors of the American Indians crossed the Bering Sea to North America about 20,000 years ago. They were followed about 2,000 years ago by the first Eskimos. About a million Indians lived north of Mexico mostly as scattered tribes. In Mexico, the Aztecs created a great civilisation, while in Central America the Maya civilisation grew up' (p.233). Taking these facts into consideration, it would not be a far-fetch conclusion to say that the 'Maya-myth' of the *Surya Siddhānta* is not an interpolation but reminiscent of the relationship of the Mayan Civilisation with Indian astronomy and architecture.

In Indian mythology, Maya happens to be the chief architect of the city of Lankā, the capital city of the kingdom of Ravana. It is but too significant to be ignored as stated in

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the annals of Indian astronomy. Almost in all the *Siddhantas* calculation of civil days (*ahargana*) begins either from the sunrise or from the midnight at Lanka. As for example:

> *Labdhonarātrirahitā Lankāyāmārdharātrikah*
> *(Surya Siddhānta, MA, 1.50)*
>
> *Lankānagaryāmudayācca bhānostasyaiva vāre prathamam-babhuva (Siddhānta Siromani, MA, 1.15)*
>
> *Lankāyāmarkodaye caitrashukla pratipadārambhe rka dinādāvaswinyādau kimstudhnādau raudrādau kālavrttih.*
> *(Visnudharmottare Brahma Siddhānte Srimad Bhāgavad Vrgu Sambade Bhagavat Vākyam)*
>
> *Caitrasitāderudayadvānordina māsa varsa yugakalpāh*
> *Srstyādau Lankāyām samam pravrttā dinerkasya*
> *(Brahmasphuta Siddhānta, 1.42)*
>
> *Evam srstyāditah siddhāh Sarvelankārdharātrikāh*
> *(Siddhānta Darpana, 3.26)*
>
> *Lankārkodayakālikādivisadām ksetramsakādidhruvah*
> *(Siddhānta Darpana, 3.58)*

It is commonly observed that fastidious scholars of mathematics and astronomy usually shear the mythical aspect off the above statements and try to identify Lanka with a particular place. By this type of decipherment, the myth is deprived of its legitimate mystery and strange conclusions are drawn, as Arun Kumar Upadhyaya has done:

> Lanka is south of Ujjain at equator by definition. The country named Lanka is very close to it, but slightly towards east and north. Hence Lanka has been assumed as a point on equator on Longitude of Ujjain. Yamakoti and Romaka have been described as *pattana* (i.e. ports). Hence they must be coastal towns 90° east and same longitude west of Ujjain 75°54" E. Thus *Romaka pattana* could be Conakry of Guinea in West Africa which is a port at that

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> longitude and close to equator. 'Conakry' like 'Konark' means a port. Yama means south direction and Koti is end point of a landmass protruding in sea. That is south-eastern tip of south island of New Zealand or south-eastern tip of New Caledonia (Nouma) which is also a port very close to south tropic near equator. Nauru island is almost near equator at that longitude, but it is not a Koti, but a coral island. However it is very close to Kiribati islands where huge stone structures are found. At the location of Siddhapura, the town nearest to equator is west of Mexico – At present near lake Chapale or Guadalajara town. Nearby huge pyramids exist which were constructed to mark the end of east direction as remarked in Vālmiki Rāmāyana (*Kiskindhā Kānda*).
>
> *Siddhānta Darpana*, vol. II, A K Upadhyaya IPS (ed.), Nag Publishers, Delhi, pp.861–862, 1998; also *Hindu Astronomy*, G R Kaye, p.52

Instead of actuating a postal address for the mythical place name, it would be more viable if we interpret it as a 'basic metaphor' (as defined by George Boas, *The Limits of Reason*, p.71). Actually, Lanka, at least in Indian astronomy, is a metaphor for the place where the rays of the sun fall on a fixed point every day throughout the year irrespective of the periods during which the sun moves northwards or southwards (*Uttarāyana* and *Daksināyana*). In order to calculate the movement of stars and planets, a fixed point with respect to the Primum Mobile is necessary at the outset. In fact, a Lanka can be built anywhere by means of architectural engineering and Maya, first, had been able to construct it. To identify it with 'Polannarua' (Paulastyanagara) in present-day Sri Lanka (A K Upadhyaya, *Siddhānta Darpana*, vol. II, p.90) is a stint for sterilisation of the meaning.

Another basic metaphor of Indian astronomy is 'Meru', the mountain peak. Brahmagupta says:

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> Manifold are the opinions of the people relating to the description of the earth and to mount Meru, particularly among those who study the Puranas and the religious literature. Some describe this mountain as rising above the surface of the earth to an excessive height. It is situated under the pole, and the stars revolve round its foot, so that rising and setting depends upon Meru... The day of the angels who inhabit Meru lasts six months, and their night also six months.

> Āryabhatta who taught that the earth was a rotating sphere, argued that Meru had no absolute height. The Puranas, however, make it 80,000 or 86,000 *yojanas* high, etc. ...Albiruni pointed out that the Hindu conception of Meru was similar to that of the Zoroastrians, who place at the centre of the world the mountain Girnagar.
>
> Cf. *Hindu Astronomy*, p.38

Samanta Chandrasekhar has discussed about it in his *Siddhānta Darpana* (ch. 18) with novelty. According to him, Meru is eighty-four *yojanas* high, not 84,000 *yojanas* as some Puranas say. The manifold opinions themselves are proofs of its metaphorical existence. As Upadhyaya concludes:

> This (On equinox day when the sun has 0° Kranti, then in part eclipse of moon, shadow of Meru within earth's shadow will be 4 *Kalās* more) can be seen on moon only in part eclipse against bright portion of moon. Neither shadow of Meru is seen, nor it is visible to sailors, because it is not a mountain at all. It is a projection of Earth's axis.

But is not the Earth's axis imaginary? Can an imaginary axis have a real projection of its shadow on the surface of the moon? Here lies the mystery of the metaphorical existence.

Chandrasekhar has actually marked during partial lunar eclipse that the shadow of the earth is being increased by four *Kalās*. So this increased shadow must correspond to a

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proportional height above the surface of the earth. The mount Meru ought to be identified with this height. As this cannot be identified with geographical localisation, it must be comprehended metaphorically, but nevertheless realistically. This spectacular discovery of Chandrasekhar pertains not only to his power of observation but also to his unique way of using the lunar eclipse, i.e. a natural phenomenon for experimenting the truthfulness of basic astronomical metaphors.

In order to express the experience or idea with any nearness to Nature itself, a language has to be crafted 'which is at once intuitively metaphysical and revealingly poetic, admitting significant and living images as the vehicle of a close, suggestive, and vivid indication – a language such as we find hammered out into a subtle and pregnant massiveness in the Veda and Upanisads' (*The Life Divine*, Sri Aurobindo, p.323). When we think of the mutual inclusion of the cosmic and the poetic, the world in the poet, the poet in the world, all in the poet and the poet in all – for this is the universal experience – we evidently travel beyond the language of the normal reason. We have to go below the clear surfaces of things on which the mind dwells, to tempt the vast and obscure, to penetrate the unfathomable depths of consciousness and identify ourselves with states of being those that are not our own. Human words are poor tools in such a situation, but at least we may devise in it some symbols and figures, return with some just expressible hints which will help the light of the soul and throw upon the mind some reflection of the ineffable design.

Alone of the Aryan tongues, the present structure of the Sanskrit language still preserves the original characteristics of the Aryan structure which, according to Sri Aurobindo, proves that regular and systematic processes of Nature are at the basis of all phenomena of sound and speech. Analysing

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the origin, growth, and development of human language as it is shown to us by the embryology of the language ordinarily called Sanskrit and three ancient tongues, two dead and one living, which have evidently come at least into contact with it, the Latin, Greek, and Tamil, he says:

> But substantially the whole of the language i.e. Sanskrit with all its forms and inflexions is the inevitable result of the use by Nature in man of one single rich device, one single fixed principle of sound formation employed with surprisingly few variations, with an astonishingly fixed, imperative and almost tyrannous regularity but also a free and even superfluous original abundance in the formation. The inflexional character of Aryan speech is itself no accident but the inevitable result, almost physically inevitable, of the first seed selection of sound- process, that original apparently trifling selection of the law of the individual being which is at the basis of all Nature's infinitely varied regularities. Fidelity to the principle already selected being once observed the rest results from the very nature and necessities of the sound-instrument that is employed. Therefore, in the outward form of language, we see the operation of a regular natural law proceeding almost precisely as Nature proceeds in the physical world to form a vegetable or an animal genus and its species.
>
> *The Origins of Aryan Speech: The Secret of the Veda,*
> Sri Aurobindo, 1996, pp.579–80

This is of course one of the reasons why the astronomer-poets of India have invariably taken up Sanskrit as their medium of expression. Moreover, as Dr Raja Rāmānna says:

> Sanskrit enjoys a scientific base like no other language in the world. It has the most logical base for information transfer not only for spiritual purposes but also for conveying scientific thought. Its rules were framed by Pānini, as far back as in 500 BC to construct words and

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> parts of speech with a precision parallel to that found in the geometry of Euclid. Such scientific nature of the Sanskrit language has been pointed out by the renowned scientists of the world from time to time. Due to its thorough competence of all kinds of knowledge-expression, the exponents of the Vedas chose this language as their media of thought expression. The Vedic seers (*Rsis*) propounded different disciplines of learning e.g., Philosophy, Psychology, Mathematics, Medicine, Military Science, Chemistry, Engineering, Aeronautics etc. smoothly in Sanskrit language. The media, if faithful and successful, must possess the traits and qualities of its master discipline which it conveys. So the objectivity, accuracy, exactness, brevity and truthfulness which are the salient features of Science are also found in Sanskrit language. Laws and formula framing by way of brevity and exactness is the common practice of scientists. The same trend existed much before in Sanskrit writing which is clearly visible in the Vedic language. Thoughts in the Vedas have been expressed in very brief sutras/suktas which are formula-l ike and lots of explanation is required at each step.
>
> *Sanskrit and Science*, Dr Raja Ramanna,
> The Bhāratiya Vidya Bhawan, Bombay, 1982

Nature, as previously viewed is the gallery of all patterns. There are relationships between things, or habitual consequences of certain events occurring, and we can introduce symbols and rules to represent those relationships. Gradually, this process creates the structure which, we call *Siddhānta* or 'mathematical astronomy'. All discussions of the universe and its contents lead inevitably to mathematics, no science exists without it. This does not mean that all science has to be bristling with algebra and equations. Sometimes, the patterns that mathematics codifies can be handled quite easily with ordinary language. The words could be replaced by symbols and equality signs, but it is not imperative. Only when the relationships become

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complicated, and the number of variables large, does it become expedient to replace them by symbols just as ordinary language often resort to using acronyms and abbreviations. Mathematics is bigger than science which only needs some of the kaleidoscope of possible patterns to describe the physical universe. Mathematics can offer descriptions or predictions of the things that occur in Nature and thus it is not a science. So are the *Siddhantas*. Like mathematics, the *Siddhantas* cannot tell whether certain things exist in physical reality. They are often engaged in investigating structures which are unrealistic in the sense that they do not appear to offer a description or explanation of anything real. Remarkably, it has often turned out that patterns which were originally investigated by mathematicians for purely aesthetic reasons turn out to play a key role in the structure of the physical world. *Siddhānta* is a metalanguage for mathematical astronomy which again is a metalanguage of Nature itself. Metalanguage can be defined as:

> We can make statements in the language of one of our systems, but we are also able to make statements about that language using another one. For example, '2+2=4' is a statement of arithmetic, but '2+2=5 is false' is a statement 'about' arithmetic. Likewise with human languages: We can talk in German about sentences in English. The language consisting of all the statements about another language is called its 'metalanguage'. In our last example, German is being used as a metalanguage for English. Any metalanguage can in turn have its own metalanguage.
>
> *Impossibility*, Prof. John D Barrow, Vintage, 1999, p.195

Mind is capable of two types of knowledge, i.e. the rational and the intuitive, which have traditionally been associated with science and religion respectively. But the view that mathematics is nothing but an extremely abstracted and compressed language does not go unchallenged. Intuitionism

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was initiated in 1924, by the Dutch mathematician L E J Brouwer as an alternative response – distinct from that of formalism – to the paradoxes (such as Russell's) that can arise when too free a use of infinite sets is made in mathematical reasoning. If there is an intuitive element in mathematical reasoning there is also a rational element in Siddhantic theology. The seeing plays the most important role in Siddhantic epistemology for seeing is at the basis of knowing. Knowing is impossible without seeing, all knowledge has its origin in seeing and both are found generally united in Siddhantic philosophy. It is a synthesis of rationalism and intuitionism as envisaged in the following Vedic Hymns to the deity *Jñāna* or the deity of the knowledge of the supreme Brahmā.

Aksanvantah karnavantah sakhayo
manojaveshvasamā bavubuh
Ādaghnāsa upakaksāsa u tve
hradaiva snātvā u tve dadrsre.

R V, X.71.7

Friends possessing eyes, possessing ears, were (yet) unequal in mental apprehension; some seemed like pools reaching to the mouth, others reaching to the loins, others like pools in which one can bathe.

Uta tvah pasyan na dadarsa vācamuta tvah
srnvān na srnotyenam
Uto tvasmai tanvam vi sasre jāyeva patya
Usati suvāsāh.

R V. X.71.4

One man indeed seeing speech, has not seen her; another man hearing her has not heard her, but to another she delivers her person as a loving wife, well attired, presents herself to her husband.

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Chapter IV
THE RENAISSANCE

In his description of the Renaissance, Burckhardt lays much stress on the naturalism of the period, and represents the turning to empirical reality, 'the discovery of the world and of man', as the most fundamental factor in the 'rebirth'. In any case the real turning point does not occur until the eighteenth century and the modern age really begins with the enlightenment, with the idea of progress, and with industrialisation. By the sixteenth century, science had invented gunpowder and the mariner's compass. The discovery of America and India had expanded the ancient geognosis. In the 1450s, the invention of printing had already come spreading rapidly through Europe. The spread of printing and the mass production of books were of enormous importance as a way of spreading new ideas. Ocean navigation gave a new impetus to the study of astronomy. The seventeenth century with the telescope, the science of dynamics, and the law of gravitation, heralded the triumph of the scientific outlook.

From one point of view, the Renaissance was a 'Revival of Learning', particularly of Greek learning; resulting from the transfer to Italy of what was left of the old Greek civilisation. When the Western, or Latin, half of the Roman empire went down before the irruption of the Barbarians, the eastern, or Greek half, with its capital at Constantinople, had managed to survive. But for sometime now the Moslems, long since checked in the West, had been pouring into Europe from a new angle. In 1458, the Turks captured Constantinople. Anticipating this disaster, the Greek

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scholars, for sometime, had been streaming westward to Italy, bringing with them the manuscripts which enshrined the old literature and science. Italy thus became the fountainhead of what was called the New Learning.

The Revival of Learning notably influenced astronomy in the fifteenth century. This was partly through the recovery of ancient astronomical books in original Greek and partly because, in the spirit of the time, men started to observe the heavens again for themselves. The science was stimulated by the demands of sailors for the nautical instruments and tables they needed for voyaging on their new ocean highways and, like all other branches of learning, astronomy profited by the invention of printing.

Modern science, as it developed in Europe since the Renaissance of the sixteenth and seventeenth centuries, was inherited from the science of Greek antiquity, from science in the Arab-speaking world, and from the science of the European Middle Ages all these scientific traditions being themselves in filiations with one another, although not in a linear manner. It was also indebted to other traditions such as those from the East, through the complex and innumerable exchanges from antiquity and the Middle Ages to the European Renaissance, between the East and the Mediterranean shores and from there to western Europe. We know about caravan trade, about military and political conquests, and for sure the exchange of ideas and knowledge has accompanied them, though the history of this period is yet to be fully uncovered. Modern science itself began in Italy and in regard to the science of Nature, its first period culminated with Galileo, and the second period began with the foundation of the London Royal Society in 1662 and the Academic des Sciences of Paris in 1666. J Needham has put it in a 1970 essay reflecting on his own approach as:

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> My collaborators and I have all along assumed that there is only one unitary science of Nature, approached more or less closely, built up more or less successfully and continuously, by various groups of mankind from time to time. This means that one can expect to trace an absolute continuity between the first beginnings of astronomy and medicine in ancient Babylonia, through the advancing natural knowledge of medieval China, India and the classical World, to the breakthrough of late Renaissance Europe when, as has been said, the most effective method of discovery was itself discovered.
>
> Cf. *Situating the History of Science*, OUP, 1999, p.44

There are periods when art is turned in the direction of science, just as there are periods when science is turned in the direction of art. In the early Renaissance the truth of art is made dependent on scientific criteria, whilst in the latter Renaissance scientific thinking is in many cases shaped in accordance with artistic principles. The perspective in painting of the Quattrocento is a scientific conception, whereas the Universum of Kepler and Galileo is a fundamentally aesthetic vision. Dilthey is right when he speaks of the artistic imagination in the scientific research of the Renaissance, but one could speak with equal justification of the 'scientific imagination' in the artistic creation of the early Renaissance (*The Social History of Art – 2*, Arnold Hauser, Routledge, 1962, p.67). The scientific conception of art, which forms the basis of instruction in the academies, begins with Leon Battista Alberti. He is the first to express the idea that mathematics is the common ground of art and the sciences, as both the theory of proportions and of perspective are mathematical disciplines. (Ibid., p.56)

As the sea-route to India was discovered and Vasco de Gama, the Portuguese sailor reached the south-western coast of India's Calicut in May 1498, India came in direct

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contact with the European Renaissance. The Portuguese, the Dutch, the Danes, the English, and the French formed companies for their Indian and eastern trade. In course of time, their ambitions grew. They came as traders but stayed on to rule. However, it should not be forgotten that an outside historical influence is never the ultimate reason for an intellectual revolution, for such an influence can only become effective if the preconditions for its reception are already in existence. It was natural that with the rise of the British power in India, the Indian society should come under the influence of the West. But it was also true that the society was permissive to external influence. The people themselves felt attracted towards many useful things of the West such as the introduction of railways, electricity telegraph, etc. In the beginning, the people of India came in close contact with the Europeans through trade and commerce. The successive conquests of territories by the European companies led the way to the establishment of the British empire in India. In course of time the British introduced the English language by setting up English schools in different parts of the country. The Western science, philosophy, literature, and thought greatly attracted the Indian mind. The advanced thinkers in India themselves became the advocates of European learning. The European missionaries began to preach Christianity in India which paved the way for a religious reform movement within the domain of Hinduism in addition to outright conversion. The spread of Western learning was also invigorated by the establishment of printing press in India. The palm-leaf manuscript tradition of Indian learning could not withstand the onslaught caused by the printing machine.

In the first quarter of the nineteenth century the impact of the West created a controversy as to what should be the new education policy in India and it was known as the

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Occidentalist-Orientalist controversy. The Occidentalists or Anglicists under the leadership of Raja Ram Mohan Ray vehemently opposed such views of the Orientalists which purported that Sanskrit, Arabic, and Persian should be the languages of higher education. When the controversy was at its peak, Lord William Bentinck came to India as Governor General in 1828. It is said that of all the acts associated with the administration of Lord Bentinck (1828–35) there was none more important or of greater consequence than the new education policy which was based on the establishment of English as the official language of the country. The chief architect of this British Education Policy for India was, of course, Lord Macaulay, who came to India in the year 1834 as the law member in the Governor General's council.

Condemning the Orientalists, early in 1835, Lord Macaulay submitted his famous minute on Indian education for the consideration of the government. In the minute he had contented that 'a single shelf of a good European library was worth the whole literature of India and Arabia' and the classical languages of India contained 'medical doctrines which would disgrace an English farrier, astronomy which would move laughter in girls at any English boarding school, history abounding with kings thirty feet high and reigns thirty thousand years long, and geography made of seas of treacle and seas of butter.' He suggested: 'We must at present do our best to form a class, who may be interpreters between us and the millions whom we govern, a class of persons Indian in blood and colour, but English in tastes, in opinions, in morals and in intellect. To that class we may leave it to refine the vernacular dialects of the country, to enrich those dialects with terms of science borrowed from the Western nomenclature, and to render them by degree fit vehicles for conveying knowledge to the great mass of the population.' (*Selection From Educational Records*, W H Sharp, Part I, p.174)

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Accordingly on 7 March 1835, a resolution was passed by the government which declared: 'His lordship is of opinion that the great object of the British Government ought to be the promotion of European Literature and Science amongst the natives of India, and that all the funds appropriated for the purpose of education would be best employed on English Education alone.' (Ibid., pp.130–131) S N Sen says:

> Unlike Europe, modern science did not develop in India from her traditional sciences. These sciences arrived in India with the European Jesuit Missionaries, fortune seekers and colonists from the eighteenth century and from still earlier times. They included medical men, naturalists, engineers, mathematicians, botanists, and the like. The Jesuit missionaries, for example, started their activities soon after the establishment of their mission under S Francis Xavier. ...During the seventeenth and eighteenth centuries, several members of this order... determined the latitudes and longitudes of different parts of India from where they operated... In astronomical surveys, Rev. William Smith (c. 1775); Thomas Deane Pearse (1741–89); Ruben Burrow, assistant to Maskelyne, astronomer royal before coming to India; Michael Topping (1747–96), responsible for the foundation of the Madras Observatory (1790); and a few others made notable contributions.
>
> *The Cultural Heritage of India*, vol. VI, XVI–XVII

On the other hand, among the Orientalists there were several British officers to whom the Eastern knowledge appeared invaluable. Some of them were profound scholars. They read the classical languages of India with great endeavour and fervour. The notable Orientalists were H H Wilson, H T Princep, and W H Macnaughten who envisaged that the metaphysical sciences, as found in Sanskrit and Arabic writings, were fully as worthy of being

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studied in those languages as in another. The arithmetical and algebra of the Hindus led to the same result and were grounded on the same principles as those of Europe; and in the madrasa, the elements of mathematical science which were taught were those of Euclid.

Long before the Occidentalist-Orientalist controversy took place, Indian astronomy had already created considerable interest among some of the Europeans. In 1691, G D Cassini had published an account of certain astronomical rules brought from Assam by M de la Loubiere, and thus as the most renowned astronomer at that time in France, had given a first advertisement, and soon after, in an appendix to the *Historia Regni Graecorum Bactriani* of T S Bayer, some account of Indian astronomy had been given, together with a dissertation by Leonard Euler. In 1769, Le Gentil had gone to Pondicherry to observe a transit of Venus and in 1772 had published an account of Indian astronomy. One of the important results of this publication was the interest taken in it by Jean Sylvain Bailly, who, in 1787, published his *Traite de L'astronomie et orientale.* Bailly's work had attracted much attention from scholars like Laplace and Playfair. In 1792, Playfair had addressed the Asiatic Society and had suggested a systematic search for works on Indian astronomy. Gradually, a host of scholars like S Davis, Sir William Jones, John Bently, Colebrooke, Sir W Barker, and W Hunter had stepped in with their notable contributions. (*Hindu Astronomy*, G R Kaye, Cosmo, 1981, p p.1–5)

The real foundation of a proper knowledge of the ancient Indian astronomy was laid by Weber (1860–68), Whitney (1858) and Thibaut (1877–89). Weber had translated the *Jyotiṣa Vedanga*, Whitney had translated the *Surya Siddhānta* and Thibaut, the *Pañcasiddhantika* of Varāhamihira. These contributions endorsed the question of the connection between the later Indian astronomy and that of the Greeks,

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and the attention of the Orientalists was consequently directed to the earlier periods that had been designated as Vedic and post-Vedic. In 1893, H Jacobi and B G Tilak independently suggested that the Vedic works contained important astronomical evidence of their own antiquity; but their views were strongly opposed by Whitney, Oldenberg and Thibaut. Thus another controversy arose. The general result of this controversy was that while many European Orientalists rejected Jacobi's and Tilak's hypothesis, in India itself they gained ground. Due to the consciousness created by the Orientalists, several astronomical ma nuscripts, both original works and commentaries, had been critically edited, translated, and commented upon by a galaxy of scholars in India and abroad throwing new light on the subject. Then it appeared that the cult of Indian astronomy did not cease with the produce of Bhaskara-II (c AD 1200). But 'the medieval period from the twelfth to the eighteenth century, though largely marked by the secondary activities of the commentators, did occasionally produce brilliant minds with significant contribution to their credit. (S N Sen, *The Cultural Heritage of India*, vol. vi, p.83)

When Europeans arrived and started their survey and other scientific operations with much improved and more powerful instruments, the ancient and medieval science of astronomy lost much of its force and value. Telescopes appeared on the rooftops of houses of a few private individuals and some resourceful officials of the East India Company in Madras and Calcutta. Jai Singh, a ruler of Rajasthan (1686–1743), had set up five observatories and with them, had made accurate observations. These institutions contained enormous instruments of masonry. Though magnificent, they were seldom used after his death. The era of telescope technology pushed them rapidly into obsolescence.

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After, T D Pearse (1741–89) of the Bengal Artillery who had undertaken a series of observations of latitudes and longitudes from 1774 to 1779 and again from 1781 to 1784 during his marches to and from Madras in the Mysore War, William Petrie, a member of the Madras government started another series of observations in 1787. He possessed two three-inch achromatic telescopes, two astronomical clocks, and a transit instrument which formed the nucleus of instrumentation of the first observatory established in Madras by Michael Topping in 1790. The multilingual inscription on its pier says: 'Posterity may be informed a thousand years hence of the period when the mathematical sciences were first planted by British liberality in Asia' (*The Cultural Heritage of India*, vol. vi, p.261). The first recorded use of a telescope in India by any amateur is of course by the Jesuit, Father Richaud, at Pondicherry who in December 1689 discovered a comet and also that Alpha Centauri was a double star. Besides telescope, the introduction of celestial photography ushered a new era in astronomy. The naked-eye observation lagged behind ever since. The antiquated model of the universe that held sway, was overthrown by the works of Copernicus, Galileo and Newton.

Situated on the eastern coast of India and in a sense serving like a corridor to the north and the south, Orissa was open to cultural influences from all sides, and in course of history, it could achieve a remarkable synthesis in her own culture. Since 1634, when Emperor Shah Jahan, granted the permission to the English traders to establish a factory at Pipli on the Subanrekha in Balasore region, Orissa had come in direct contact with the European civilisation. John Beams says: 'To Balasore belongs the honour of containing the first settlement made by our countrymen in any part of the Bengal Presidency... Calcutta was not founded till 1690 and it is curious that we hear nothing of Pipli in all these

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events. It would seem that Balasore had become the more important place of the two.' (*The History of Orissa Under the Mohammedan, Maratha and English Rule*, Journal of Royal Asiatic Society of Bengal (JRASB), cf. *A History of Orissa*, N K Sahu (ed.), vol. II, 1956, pp.310–13)

It is stated that from Clive to Cornwallis, the East India Company tried to capture Orissa but failed. In 1798, Lord Wellesley came to India and he conquered Orissa during the second Anglo-Maratha war, in 1803. John Beams says: 'As the early years of our rule in Orissa were fertile in changes, and worked a complete revolution in the position of the classes connected with the land, it would have been interesting to trace the progress of our laws and their effect upon the province' (Ibid., p.320). Broadly speaking, despite the disastrous effects of the British occupation, the modern period in Orissa began with its contact with the West and the arrival of the Christian missionaries in Orissa in growing numbers also gave a fillip to the new awakening. With the Mughal and Maratha rule in total disintegration and with the new British administration careering without a thought to the cultural wants of the people, it was inevitable that culture should be in jeopardy and civilisation at its lowest ebb; no wonder, eighteenth–nineteenth century Orissa was a devastated land. The old order was torn into fragments and there were no signs as yet of a new order springing up from the wreckage and redeeming the time. The British having brought not only the alluring tools of trade and invincible implements of war with them but also their system of education which inevitably, if slowly, altered the aspect of affairs in Orissa.

Orissa in its great days of sovereignty vis-à-vis the Muslim states of Bengal and Bihar was a haven for the Hindu people of Bengal. Like Mithila, which somehow retained its internal control right down to the Mughal period, Orissa was also a

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centre of Sanskrit learning and Hindu culture, and during this time Puri became completely integrated with Bengali Hindu culture and religious life as much as Varanasi (*The People, Language and Culture of Orissa*, Prof. S K Chatterji, Orissa Sahitya Akademi, 1966, p.79). The Sanskrit learning of Orissa had its great contribution in the sum total of mediaeval Sanskrit literature, for the whole of India. Orissa had a long succession of scholars who were great in various subjects in Sanskrit, e.g. medicine (Madhava-Kara), grammar (Mārkandeya), rhetoric and poetics (the eminent Viswanāth Kavirāja and his great uncle Chandidāsa), Sanskrit drama (Ramananda Raya), and a number of other eminent names in mediaeval Sanskrit literature. Orissa had given to India some of the great poets and dramatists of classical Sanskrit literature, like Bhatta Nārāyan (the author of the drama *Veni Samhāra*, AD eighth century), Murari Mishra (author of the *Anargha-Rāghava* c. AD 1000), Krishna Mishra (author of the *Prabodha-Chandrodaya Nātaka* c. AD 1050), Sri Harsha (the illustrious poet of the great *kāvya*, the *Naisadha-Carita* c. AD 1100), and Jayadeva (the author of the *Gita Govinda* c. AD 1200).

As a maritime nation Orissa, i.e. ancient Kalinga and Utkala had occupied a distinct place and so great was its fame that Kalidāsa, the illustrious poet of India had referred to the king of Kalinga as the 'Lord of the Sea'. The history, legends, inscriptions, and architecture of Orissa as well as of Simhala (Sri Lanka), Java, Bali, Sumatra prove the important role of Kalinga in the establishment of commercial and cultural links with the lands of South-east Asia. It is evident that seafaring would not have been possible without a fair amount of astronomical knowledge like determination of longitude, latitude, and direction. This is why the Indian *Siddhantas* used to deal with these three questions invariably in an exclusive chapter called *Triprasnādhikāra*. Even during the reign of Aurangzeb (1658–1707), Balasore in Orissa was one of the main centres of shipbuilding and navigation (*The*

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Cultural Heritage of India, vol. VI, p.203). By the time the British came, the technique of shipbuilding had acquired a fairly high standard of perfection in the country. But things changed with the entry of European navigators and traders who gradually exterminated the indigenous navigation, shipbuilding, and overseas trade. With the decline of the naval trade astronomical study also waned.

Located on the sea coast and known to early sailors on Orissan coast as the Black Pagoda, the Sun Temple at Konark (c. AD 1250) is a wonder even in ruins and rightly finds a place in the world heritage list, being a monument of world importance. Originally conceived as a gigantic chariot on twenty-four huge wheels drawn by seven spirited studs, the temple presents a unique astronomical cult of religion and justifies the statement: 'The temple is built in the likeness of the universe and is its reduced image. The architect of this world image, the temple is looked upon as descended from, and in his sphere alike to Visvakarman, who made all that exists in the Universe' (*The Hindu Temple*, Stella Kramrisch, vol. I, pp.10–11, University of Calcutta, 1946). As the legend ascribes, it is nevertheless evident that it was not merely a temple but an observatory. The author of the *Ain-i-Akbari*, Abul Fazl has observed:

> There are nine flights of steps after ascending which, you come into an extensive enclosure where you discover a large dome constructed of stone upon which are carved the sun and stars and round them is a border where are represented a variety of human figures, the different passions of the mind, some kneeling, others prostrated with their faces upon the earth, together with minstrels and a number of strange and wonderful animals, such as never existed but in imagination.
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> vide Gladwin's translation, cf. *Orissa* by Andrew Stirling, ed. N K Sahu

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As mentioned in the *Descriptive Catalogue of Sanskrit Manuscripts*, vol. IV, *Jyotis* and *Ganita* mss., (ed.), K N Mohapatra, Orissa Sahitya Academy, 1963, Orissa had evidently produced eminent astronomer-poets in the past, and Satānanda (c. AD 1100) was the most eminent astronomer whose name has been reverently mentioned in the magnum opus of Bhaskar II, the *Siddhānta Siromani* , as '*Satāyuh Satānanda evam pradistah...*' (Ss 1–25). From AD 1100 to the conquest of Orissa by the Afghans (AD 1568) and subsequently by the Mughals and the Marathas, Orissa continued to produce astronomer -poets and her record in this department of intellectual pre-eminence is higher than in many other parts of India, when we consider the independent renderings of astronomical treatise by Orissan astronomer-poets. But the fate of Orissa from the middle of the sixteenth century began to sink to its lowest ebb and her history entered into a period of constant chaos and lasting decay until Orissa came under the British Rule (AD 1803). During the long period of subjugation O rissa had been reduced to the size of a small principality with no language, no culture, no separate existence, and no independent thought and action. Andrew Stirling narrates the state of affairs at the advent of the British occupation of Orissa in his brief enumeration of Orissan history (1822):

> The administration of the Marathas in Cuttack was, as in every other part of their foreign conquests, fatal to the welfare of the people and the prosperity of the country, and exhibits a picture of misrule, anarchy, weakness, rapacity, and violence combined, which makes one wonder how society can have been kept together under so calamitous a tyranny.
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> *Orissa*, cf. A History of Orissa, vol. II, (ed.) Dr N K Sahu, S Gupta India Ltd., Calcutta, 1956, p.260

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Another historian of this period, W W Hunter, observes that throughout the length and breadth of the province with its population of two-and-a-half million of souls, all was darkness and superstition. 'But wretched as the state of Orissa had been under the Mughals, a half century of deeper misery remained for it under the Marathas. The memory of these fifty years haunted the whole population like a nightmare, long after it passed under British rule.' (W W Hunter, 1870, Ibid., vol. II, p.157)

One should not be oblivious to the fact that the year of Samanta Chandrasekhar's birth, 13 December 1835, coincides with the commencement of the Orissan renaissance. Around the year a number of historic events sporadically came into being. As the first experiment of the Downward Filtration Theory of Macaulay's educational policy in Orissa, an English school had been set up at Puri in November 1835. Cuttack Mission Press, the first printing press in Orissa, was established by Rev. A Sutton in 1837, a year later. The first book on European elementary science and astronomy in Oriya language had already been published in three parts by the Calcutta Book Society in 1830 and 1832 respectively and the author was Rev. A Sutton. The book (*Padārtha Vidyā Sāra*) had remained as the approved textbook for over forty years, and set up the scientific trend of the subsequent generations. In 1838, *The Wonderful Advantage of a Pilgrimage to Jagannath* was published in the Oriya language by the missionaries vehemently criticising the religious cult of Orissa.

Since their arrival (12 February 1822) in Cuttack, the missionaries had started to set up Christian schools through which Christianity could have been extensively propagated. The Bible had already been translated into Oriya (1807–09) and a number of religious tracts, gospels and pamphlets had come out as a part of their crusade against the idolatry and

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superstition prevalent in Orissa. Conversion had started since 1928 and the first Oriya to be converted was none other than a Brahmin.

English education and Western culture apart, innovations such as colonial imposition of a new discipline enforced by the clock-time concept, the print culture and the vernacular space it opened, and other factors of various dimensions were instrumental for creating hierarchical stratifications, change, and mobility in the colonial middle class. The growth of a clerical lower-middle-class world as particularly distinct from the well-known world of prominent intellectuals, of small but growing number of educated women (mission girls' school had been established at Cuttack the same year in which Samanta Chandrasekhar was born) and of an upwardly mobile lower-caste men are suggestive of significant social changes, hopes, and frustrations. It is against the background of this changing, multilayered and, to a certain extent, frustrating colonial middle-class society that the work of Samanta Chandrasekhar has to be viewed.

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Chapter V

THE MAKING OF THE MAHĀMAHOPĀDHYĀYA

Samanta Chandrasekhar, the *rara avis*, who gave his countrymen 'an upturned face and bade contemplate the heavens and raise looks to the stars' (Ovid, Metamorphoses 1.85) was a phenomenon. Born in a decaying aristocratic royal family, on 13 December 1835 (vide 'Date of birth of Samanta Chandrasekhar', P C Naik, *Indian Journal of History of Science*, 35.2, 2000, pp.149–160) in the tributary chiefdom of Khandaparā, Orissa, he was green with ancestral honours to stand Athanasius against the world. Many brave men lived before Agamemnon, but here was a happy man who far removed from business... tilled with his own oxen the fields that were his father's. The stars were his camp, God was his lamp. From being the Pathāni of the remote recesses of the hilly '*garhjāt*' to the holder of permanently glowing and glorious accolades and appellations like Harichandan, Mahāpātra, Mahāmahopādhyāya, Bhaskara-II of Orissa, the tulsi plant of the graveyard etc., his was a long arduous journey of cramming and craftsmanship.

In his introduction to the *Siddhānta Darpana*, Prof. Jogesh Chandra Roy had lamented:

> It is the lifelong labour of Chandrasekhar Singh Samanta of Orissa, written in a language which few men care to study in these days of English education... In these days of 'scopes' and 'meters', it may be thought useless to put forward the poor work of a Hindu whose education is in

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> no way superior to that of an astronomer of pre-telescopic Europe. And there are men, too, who have thought that much nonsense has already been written about him. ...It will be unfair to expect anything new in the work which will be useful to those who have studied European Science... The value of the *Siddhānta Darpana*, the work of an orthodox Hindu, showing errors in our current almanacs, cannot thus be overrated.
>
> *Introduction to the Siddhānta Darpana*, pp.xiii, xiv, xvii; 1899

But at variance with the run-of-the-mill estimation of Prof. Jogesh Chandra Roy, the British Royal Astronomer, E Walter Maunder had thrashingly remarked:

> The last quarter of a century has seen a striking increase in the size and efficiency of astronomical telescopes. These have opened up new fields of great interest; but in the widespread attention which they have attracted, there is some danger lest it should be forgotten that there a re fields for which the primary instrument of all, the unassisted human eye, is still available, and to which it alone is adapted, fields which even yet are far from being exhausted... Indeed in our own day the same feat has been repeated, for, as readers of *Knowledge* (vol. xxii, p.257, No. 1899) will remember, there is still living in Orissa the Hindu astronomer, Chandrasekhar who with home-made instruments and without optical assistance, has re-determined the elements of the chief members of the solar system with a most astonishing accuracy.
>
> *Astronomy Without a Telescope*, W Thacker & Co., London,
> Thacker Spink and Co., Calcutta, 1904,
> Preface to the First Impression and Introduction, p.v

In a special chapter (Section III, Ch. V) on Chandrasekhar, namely *A Modern Tycho*, he writes:

> But the work, for which the pretentious buildings of the raja of Amber were designed, has been more efficiently

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> accomplished quite recently by very humble means and by... recluse in an obscure village... In the recluse of the Orissa village, we seem to see reincarnated, as it were, one of the early fathers of science, long centuries ere the telescope was dreamed of, as he grappled with the problems which the planetary movements offered to him for solution... For be the telescope ever so good and powerful, still that which is by far the most important is the man at the eye end.
>
> Ibid., p.167

Though far away from the light of English education, Chandrasekhar was fortunate enough to receive, at an early age, education in the national language Sanskrit which was not only the latchkey of the treasure house of Indian knowledge but also, fast becoming international. Even the college science teacher of his times, Prof. J C Roy, admits that it had stood Chandrasekhar in much better stead than the modern elaborately arranged curriculum of the English schools, through which he would have been thrust, had he lived nearer a town (*Introduction to the Siddhānta Darpana*, p.xxx). His knowledge of Sanskrit was so far advanced as to enable him to compose verses in it. The famous astronomer Johannes Kepler had said:

> We do not ask for what useful purpose the birds do sing, for song is their pleasure since they were created for singing. Similarly, we ought not to ask why the human mind troubles to fathom the secrets of the heavens... The diversity of the phenomena of Nature is so great, and the treasures hidden in the heavens so rich; precisely in order that the human mind shall never be lacking in fresh nourishment.
>
> *Mysterium Cosmographicum*, qf. *Cosmos*, Carl Sagan, Ch. III

The sky lures the infant as well as the astronomer with its innumerable patterns, colours and phenomena. The

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appearance of the crescent moon in the night sky is universally the most cherished object for the child. Gradually, stars and planets allure him. Mostly the parents show the young children some of the stars to satisfy their curiosity. But Chandrasekhar's father was not an ordinary man. Himself being a learned man in astrology and computing almanac, he had successfully initiated his son into the mysteries of the sky.

At the age of ten Chandrasekhar was introduced to testing for himself the position of stars which, changed after every night and his instinctive curiosity in stargazing had developed into the habit of an ichnographic study of astronomy. His desire to know the mysterious universe was so great that he diligently engaged himself in discerning palm-leaf volumes of ancient *Siddhantas* which were existing fortunately in his family library and mastered them solely with the help of commentaries. As soon as he learnt to examine the ascendant (*lagna*) and the rules for calculating ephemeredes of planets, he was perplexed to perceive wide disagreement between calculation and observation. In fact, at that time no almanac was able to predict correctly, save the foreign nautical almanac. An unhealthy controversy was going on between the orthodox and the reformist Hindus regarding the existence of errors that had crept into the figures of the old source books in course of time. The reputation of the indigenous system of Indian astronomy was under the threat of being rejected as fraudulent but nowhere in the country was a man who had the authority and acumen for bringing it round with necessary reforms in a similarly indigenous style and manner. For a gap deeply to be deplored, Samanta Chandrasekhar rowed his, antique boat, rowed on with antique *remis velisque* (oars and sails), come what might!

As has been said by Prof. J C Roy, the clear blue vault of the heavens was his observatory and its instruments consisted of an armillary sphere and a vertical wheel as substitutes for

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modern transit and Alta-azimuth; and the time-honoured clepsydra took the place of the sidereal clock. There was the gnomon and a self-revolving instrument made of the pericarps of the bottle gourd with water and mercury. The instrument of which he made constant use was one devised by himself out of a thin wooden rod, twenty -four digits long, at one end of which was fixed another rod at right angles in the from of a T. The crosspiece was notched and also pierced with holes at distance equal to the tangents of the angles formed at the free extremity of the other rod. Though crude, this instrument (*māna yantra*) enabled him to hit the angular position of the heavenly bodies almost to the nearest degree, (*Introduction to the Siddhānta Darpana*, pp.xxi–xxii). However these crude instruments do not tell upon the lack of sophistication as much as they tell upon his outshining capability and talent.

Since he attained the age of twenty-three Chandrasekhar had been systematically recording the results of his observations and by this time his proficiency in Sanskrit poetics had become so overwhelming that he transformed the facts and figures into poetry. Soon he became a living legend in his locality.

When all the almanacs, then prevalent in Orissa, miserably failed to predict even a colossal catastrophe like that of the 1866 famine (9th regnal year of the then king of Orissa) and tens of thousands of people died like wanton flies, Chandrasekhar was deeply shocked and stepped out from his usual aversion to publicity, with his newly calculated almanac. His almanac appeared in print nex t year (1867) for the first time and from 1870 it was published every year. Perhaps this entry into the newly evolving print medium enthused him to go for a monumental work like the *Siddhānta Darpana*.

Soon after the publication of his almanac, his work was hailed far and wide. The learned association of the Temple

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of Lord Jagannāth recommended it for the observance of the daily rites (1872). The Gajapati King bestowed upon him titles. In spite of his reclusion and remoteness of Khandaparā scholars, men who mattered apart from astrologers, astronomers, and almanac makers started to sojourn in his solitaire. It was the famous Oriya poet Radhanath Ray, then the joint inspector of schools, who met Chandrasekhar at Khandaparā on one of his official visits and recognising his genius did everything to draw the attention of the government and of learned people to him. Soon came (1892) the associate professor of physical science of the Cuttack College, Mr J C Roy, but for whom the so-called redundant Chandrasekhar would have remained a persona non-grata.

No day without a line, Chandrasekhar took twenty-three years (1870–1892) to complete his work, *Siddhānta Darpana*, the magnum opus, writing on palm leaves in Oriya character. As astronomy in India, like, tantra was forbidden to be made public (*S D*, 1/99), Chandrasekhar was hesitant to bring it to light. Thanks to Prof. J C Roy that he managed to extract it from the recalcitrant author. But prior to its publication (1899) he had become so distinguished that the title of Mahāmahopādhyāya had already been conferred upon him by the then viceroy and Governor General of India (1893). Such is the way to the stars.

In the *Introduction to the Siddhānta Darpana* Prof. Roy states: 'I regard it a misfortune that the author has not found a man to introduce his work, better qualified than myself, whose daily avocations run in a different grove' (p.xiv). He admits that he does not pretend to express any opinion on the literary merits of the book but it appears to him that the metrical composition alone, apart from its value as a contribution to Indian astronomy, is such as to entitle Chandrasekhar to a high place among the writers of

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Sanskrit verses of the present day. But even his opinions on the astronomical merits of the book, in which he expresses his reservations, nevertheless substantiate to this self-assessment, as they seem today, particularly after the advancement of the principle of uncertainty, the theory of probability, the theory of relativity, and the concept of paradoxes, etc., over the period of the last one hundred years. For instance, the critics following opinion on the geocentric theory of Chandrasekhar may be scrutinised.

> It is curious no doubt to hear a man given to astronomy, maintaining with all seriousness an idea which mankind has learnt to repudiate since the days of Copernicus. And there are men who, talking glibly of the earth's movements, thought that his calculations could not possibly come out right from such wrong fundamental premises. It is needless to argue the matter with those whose rudimentary knowledge of mathematics did not enable them to understand relative motion and I would not have introduced the topic, had it not been made the sole criterion of the merits of this work... Chandrasekhar had not the advantage of our modern schools, and had not imbibed the spirit of taking such things on trust. His is a work of unaided effort, and it would be surprising if he, along with the schoolboy, talked of the movements of the earth. On the contrary, a miserable Oida translation of a Bengali compilation from English popular astronomy made him a confirmed believer in the stationary condition of the earth. The arguments put forth in the book to establish the movements of the earth, may be sufficient to satisfy those who do not try to realise the matter, but unfortunately were not convincing to a man who struggled hard to reconcile the new idea in all its bearings with his own observation.
>
> *Introduction to the Siddhānta Darpana*, pp.xiii–lxiv

The inference clearly shows that Prof. J C Roy has totally missed the sole criterion of the merits of this work, and in

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fact, of the Indian astronomy as a whole. It is quite expected from the mindset of a man who himself had been brought up under the shadows of the British colonial education and whose knowledge in the classical language and literature was only surface deep. It was not the relative motion, but the relative state of rest that the ancient Indian astronomers were anxious to know about within the all -pervading motion of the Primum Mobile and they had discovered it in the earth itself as a paradox to its movement. Had the stability of the earth been so obvious, they would not have tried to prove it. The geocentrism of Chandrasekhar's proposition was not likely to be converted by any such convincing English astronomy, as it was not merely due to the 'miserable Oida translation of a Bengali compilation from English popular astronomy', but firmly based on the Vedic astronomy. Prof. Roy's indication aims at the school textbook *Padārthavidyā Sāra* by Rev. A Sutton. Of course, it seems, as if Chandrasekhar has juxtaposed his arguments in *Sodaśa Prakāśa* and *Saptadaśa Prakāśa* of his work against this particular textbook, the Preface of which was written in a form of dialogue between inquisitive disciples and the learned teacher, the case in these chapters of *Siddhānta Darpana* being exactly similar. But in fact the same form was being traditionally adopted since the days of *Surya Siddhānta* , and Chandrasekhar had chosen to take up on that of the *Siddhānta Siromani* rather than follow it from the 'miserable Odia translation, namely *Padārthavidyā Sāra*'.

Secondly, Prof. Roy alleges that the theory of Chandrasekhar was largely affected by superstition and ethnic theology for which he was not able to accept the movements of the earth (Introduction lxvii–lxviii). These are issues too large to be casually stated like this. In his essay 'Revisiting the Needham Paradox', Aant Elzinga says:

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> The assumption that colonialism itself was the source of all progress has been shown to be patently mistaken. There is a wealth of critical scholarship to this end, showing how there was, in fact, a whole lot in the way of appropriate technologies and situated specialised knowledge in other parts of the world prior to colonisation. Some of these have survived in spite of the economic, socio-political and culturally dismantling effects of colonialism which tended to discard the indigenous and traditional as irrational while crediting western-driven development as progress.
>
> *Situating the History of Science*, OUP, pp.85–86

Siddhānta Darpana reveals characteristics that show explanations in part to have been shaped by and forming part of such cultural narratives which as such have their anchor in the nation, a country, a people, or even a region of broader speech communities. The inevitable role of God as the Unmoved Mover of the celestial sphere in the *Siddhantas* including Chandrasekhar's is an open question to be discussed even in this advanced age of sciences. In his introductory remarks on the famous book *A Brief History of Time* written by Stephen Hawking (b. 1942) who is widely considered to be the greatest scientific thinker since Newton and Einstein and presently working as a worthy successor of Newton at Cambridge, the celebrated David Duncan Professor of Astronomy (Cornell, USA), Carl Sagan attributes:

> This is also a book about God... or perhaps about the absence of God. The word God fills these pages. Hawking embarks on a quest to answer Einstein's famous question about whether God had any choice in creating the universe. Hawking is attempting, as he explicitly states, to understand the mind of God. And this makes all the more unexpected the conclusion of the effort, at least so far; a universe with no edge in space, no beginning or end in time, and nothing for a Creator to do.
>
> *A Brief History of Time*, Bantam Books, 1988

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Hawking himself concludes with these words: 'If we find the answer to that, it would be the ultimate triumph of human reason – for then we would know the mind of God.' (Ibid.)

If, it must be admitted that defining or discarding the role of God in a book of natural science does not render the author to be superstitious or orthodox, what does Prof. Roy mean by calling Chandrasekhar an orthodox and superstitious Hindu? Can't a devout Hindu be rational and scientific as a rule? Perhaps, as Chandrasekhar has identified Lord Jagannāth of Puri connotatively with the Lord of the Universe, Prof. Roy thought he was as superstitious as an idolater, but he was almost certainly mistaken.

> With the reflexive cultural turn, we find ourselves in a new discourse in which the project of comparative studies obtains a new meaning. Now the rhetorical dimension of accounts about science and their role in the promotion of particular identities, be it one of expertise or specialist disciplines, is subjected to cultural analysis. In the context we are discussing, the main question is; what is the process parallel to the one Edward Said and Martia Bernal have described as the socio-historical shaping of 'Orientalism' as a discipline pursued as unbiased professional academic study, which discounts and hides its own filiations with an overriding Eurocentristic social revolutionist cultural narrative?
>
> Aant Elzinga, 'Revisiting the Needham Paradox', qf. *Situating the History of Science*, OUP, 1999, p.104

In 1822, as is well known, European missionaries arrived in Orissa, and among them, the Jesuits designed a specific strategy of evangelisation wherein the so-called Western science and technology were used in order to seduce Oriya literati. The state of science and technology in Orissa prior to British conquest was in fact decadent, and what was left of it, the Jesuits were not at all disposed to emphasise. They

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wanted to be thought of as converting a highly cultured people, but the greater the superiority of the 'new, or experimental, science' of the West over the traditional empirical science of the Oriyas, the greater, by implication, was the superiority of the Western religion. The first book that had ever been printed in Oriya character was the Holy Bible (1807) and the first textbook on science that had ever been printed in Oriya language, Eurocentric as it were, was the *Padārthavidyā Sāra* of Rev. A Sutton (1830/1832). The strategy of their mission might be studied from a number of religious tracts which were being published castigating the worship of Lord Jagannāth, such as: (a) Futility of the worship of Lord Jagannāth (*Jagannāth Upāsanāra anupādeyatā*), AD 1811, (b) The wonderful advantage of a pilgrimage to Jagannāth (*Jagannāth Dhamaku Tirthayatri Hoi Asibare Adbhuta Subidhā*, the first book to be printed in Orissa Mission Press, 1838), (c) True Jagannāth and False (*Sat o Asat Jagannāth*, Baptist Mission Press, Calcutta, 1838); etc. The cynical and misanthropic attitude of the Jesuits and early British administrators might be properly measured through the description given by A Stirling in AD 1822.

> ...on a low ridge of sand hills dignified with the title of the Nilagiri or Nilācala (blue mountain) stands the famous temple of Jagannāth, 'that mighty Pagoda or Pagod, the mirror of all wickedness and idolatry'... and when the monster Jagannāth himself, the most hideous of all the figures, is dragged forth the last in order, the air is rent with plaudits and acclamations. These celebrated idols are nothing more than wooden busts... the contemplation of it cannot fail of exciting the strongest sensations of pain and disgust in the mind of every Christian spectator...
>
> *Orissa – Religion, Antiquities, Temples and Civil Architecture* by A Stirling, Asiatic Researches, vol. 15, 1822

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The most awful thing was that the author of the first textbook on science in Orissa was nonetheless an evangelist who had written:

> Jagannāth, the Lord of the world as the inspiring soul of all and the town of Puri or Puri Jagannāth owes its importance entirely to its connection with the temple. This Mecca of Hindustan is resorted to by pilgrims from every quarter of India. It is, as is well known, the chief seat in Eastern India of Brahmanical power and the principal stronghold of Hindu superstition.
>
> *Orissa and its Evangelisation*, Amos Sutton, 1850, p.65

Rev. A Sutton was in Orissa since 1825 till his death in 1851 and was actively engaged in the proselytisation of Orissa. Chandrasekhar was certainly not immune to the denigrating remarks of the daredevil who had declared that 'the fall of this huge, obscene, hateful Jagannāth is imminent' (*The Narrative of the Mission to Orissa*, A Sutton). With vengeance, in order to spare the vanquished and to put down the proud, Chandrasekhar tried to straiten circumstances at home, revamped the traditional weaponry at daggers drawn against the missionaries for repudiating the theory expounded by them. *Solvitur Ambulando* – the problem of reality of motion is solved by walking, says the Latin proverb. And Chandrasekhar romped his way to success hilariously singing:

> *Brahmāndakhanda bhānda sthirataradharani mandalabhr āntisounda*
> *Prodanda Englānda dantābala bala dalanakuntha kanthiraba shrih*
> *So'yam Nilādri Simhanvaya vadanadari nirgatah prāpta durgah*
> *Sphita svasyātirastu prathama biganita skandasāra prabandha.*
>
> S D, 24/158

This essay on the most important part of astronomy has come out like a lion from the mouth-cave of Nilādri

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Singh's grandson, for smashing the valour of tusker-like English scholars.

It is not that Chandrasekhar was ignorant of the merits of the heliocentric theory which was in fact known to Indian astronomers since the days of Āryabhatta (c. AD 500). Implicitly, in his all-out effort to disprove it lies a strong motif which is: *cujus regio, ejus religio* (whose the region, his the religion), so to say.

The self-laudatory simile Chandrasekhar has used for himself might be anything but not hyperbolic. More often than not he had proved his genuineness practically being put to test in front of learned astronomers including foreigners. Once he was asked to give a good account of himself by the famous Western astronomer Dr Thibaut who had edited the *Pañcasiddhantika* of Varāhamihira (*Orissa: Past and Present*, Utkala University, 1962, p.253). Before conferring the title of Mahāmahopādhyāya on him, the British commissioner, Mr Cooke, had taken a test of his talent.

The most surprising aspect of his research, his brilliant vision apart, was of course his instrument *Māna-yantra*. As to this instrument it has been said:

> Such crude instrument did not admit of being so divided as to enable him to measure a degree with any accuracy... It will be needless to compare the rates of motion of the nodes and apsides. It is possible for modern European astronomy, with instruments enabling it with ease to measure the three thousand and six hundredth part of a degree and with its engines of higher mathematics to handle intricate problems, unheard of before, to deduce the elements of orbits from a very few observations made at no distant dates. But it requires the lapse of years – nay centuries – to do the same with primitive instruments and equally primitive mathematics.
>
> *Introduction*, Prof. J C Roy, pp.xxii–xxxii

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But better than Roy perhaps Chandrasekhar knew that sophisticated machinery would not make a man a scientist. Rather it would perpetuate the servility of the people to the traders of machinery. Dependence on foreign instruments and machinery would be tantamount to acceding to the invaders' strategic regimentation in this country – this foreboding prevented him from using even a mechanical clock.

In 1960, Needham, Wangling, and Price had brought out a narrative which, with respect to the history of clockworks, tells upon the state of affairs in China. The situation in India was more or less similar. As they had shown:

> ...when the Jesuits arrived 250 years later there was extremely little to show them that mechanical clocks had ever been known in China... this situation was naturally exploited by the Jesuits in several ways. To the Chinese they emphasised as much as they possibly could the superiority of the natural sciences of early seventeenth-century Europe because by the aid of it they wished to convince them of the superiority of European religion... The general upshot was that the indigenous scientific and technical tradition of China was very much underestimated in the West p.141.
>
> Qf. *Situating the History of Science*, OUP, 1999, p.233

It is well known that Chandrasekhar had been using the clepsydra and the gnomon instead of a mechanical clock which was well within his reach. This was not the insignia of orthodox parsimony; nor he had gone off on a wild goose chase. He had verily proved that even instruments made of straws and sticks could be rung up to meet with the challenge posed by the European instruments. Nowhere in his work Chandrasekhar has relented for want of improved instrument. As to his first reaction to seeing the telescope Prof. Roy has stated: 'It was at this moment that he gave vent to his bitter regret that he had not the advantage of

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using such instruments in his younger days' (*Introduction to Siddhānta Darpana*, p.xxiii). Strangely, Chandrasekhar has expressed no such regret in his *Siddhānta Darpana* although he has not forgotten to mention his first experimental finding through the telescope provided by Prof. Roy once for all. He was sharp enough to hit upon Olbers' paradox thus, in his once-over experiment with the telescope:

Yantre yasmin satagunabrhadrsyate vimbamārāt
Tasmin drstād basukalāmiterlubdhakattaiks myabhājah
Drasturdrsti pratihatirapi syādivasāmghrimanad
Bhānoryantrāntaragatatanoryadvāyoh sāmyalabhah.

S D, 17/143

The star *Lubdhaka* (Sirius) at a distance of eight *kalās* from the sun, is still visible even when magnified a hundred times by means of a telescope. If *Lubdhaka* is as bright as the sun, the sight would have been blinded by the terrific brightness created by both. This suggests that numerous suns can never be there in the visible areas of the sky.

The darkness of the night sky has long been thought to be a cosmological paradox, because in an unchanging universe filled with an infinite number of stars the whole sky should shine with the brightness of a typical star like the sun. In 1826, H W M Olbers (1758–1840), the German astronomer, suggested that whenever one looks in the sky there must be a star, even if it is at a very long distance. Every tiny part of the sky should thus be shining like the surface of a typical star, and the whole sky should be bright. This paradox could be satisfactorily explained after the discovery of the expansion of the universe by Hubbles in 1928. Nobody had taken care of Chandrasekhar's explanation.

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Chapter VI

ORGANON OF THE UNIVERSE

The non-existent was not, the existent was not; then the world was not, nor the firmament, nor that which is above (the firmament). How could there be any investing envelope, and where? Of what (could there be) felicity, how (could there be) the deep unfathomable water (1)?

Death was not, nor at that period immortality, there was no indication of day or night: THAT ONE unbreathed upon breathed of his own strength, other than THAT there was nothing else whatever (2).

There was darkness covered by darkness in the beginning, all this (world) was undistinguishable water; that empty united (world) which was covered by a mere nothing, was produced through the power of austerity (3).

In the beginning there was desire, which was the first seed of mind; sages having meditated in their hearts have discovered by their wisdom the connection of the existent with the non-existent (4).

Their ray was stretched out, whether across, or below, or above, (some) were shedders of seed, (others) were mighty; food was inferior, the eater was superior (5).

Who really knows? Who in this world may declare it? The gods (were) subsequent to the (world's) creation; so who knows whence it arose (6)?

He from whom this creation arose, he may uphold it, or he may not (no one else can); he who is its superintendent in the highest heaven, he assuredly knows, or if he knows not (no one else does) (7).

Rg Veda, x.129, tr. H H Wilson

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In order to render the phraseology (*Nasadāsit no sadasit...*) intelligible Wilson goes on to say that we must restrict the meanings of *sat* and *asat* ('ens' and 'non-ens') to visible and invisible existence, or in Hindu cosmology to matter and spirit (*Prakrti* and *Purusa*), which in Vedic system would not, as in the *sankhya*, have a distinct existence, but would be blended and lost in the one invisible, immaterial, incomprehensible First Cause, or Brahmā, in the intervals of creation. (*Rg Veda Samhitā*, vol. VI, x.435, Nag Publishers, 1990)

The above-mentioned ideas of the *Nāsadiyasukta* is described as the basis of Indian cosmogony which has been further strengthened by the *Purusa Sukta* (Rg Veda, X.90), *Yajus* (XXXIII.74), *Taittiriyopanisad* (III 1.1/11.6), *Satapatha Brāhmana* (X.V.3.1) and elaborated in the *Siddhantas* as:

Vāsudevah param Brahma tanmurtih purushah parah
Abyakto nirgunah shantah panchavimshat parovyayah.
Prakrityāntargato devo vahirantasca sarvagah
Samkarsano' pah srstvādau tāsu virya mavasrjat.

Surya Siddhānta, *Bhugolādhyāya*, 12/13

Yasmāt ksubdha prakriti purusāvyām mahānasya garbhe
'Hamkaro' bhut khakasikhijalorbyastatah samhatesca
Brahmāndam yajjatharagamahi prstha nisthadviranceh
Visvam sasvajjayati paramam Brahma tat tatvamādyam.

Siddhānta Siromani, Bhubanakosa-1

Yattejah ksubdhamāyājanita mahadahamkāra tanmātrabhutod
Bhutāndādhisanābhyudbhava
bhubanamayāmbhojagarbhātsvayambhuh
Bhutvābhutairbhutāni tribhubana bhabananyaracayyasvadhamni
Dhyayam dhyayamyamāste sa jayati paramabrahma dhāmādidevah.

Siddhānta Darpana, 1.21

In his *Siddhānta Darpana*, Chandrasekhar has congruously quoted twenty couplets at a stretch (Ch. 18/3–22) from the

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Surya Siddhānta by way of elaborating on the creation of the universe. It follows that 'Brahmā' is the origin of all, the prime cause of all causes. He is the indistinguishable formless magnitude, indolent, lax, the One besides whom there is nothing else existent. Brahmā is the alpha and the omega.

A principle of active will (desire, *kama*) and knowledge superior to mind (consciousness, maya) and Creatrix of the worlds is the intermediary power and state of being between that self-possession of the One and this flux of the many which we call the universe. As part of the Brahmā, Samkarsana adopted embodiment and entered into the Nature. As a result, the golden egg (*hiranyagarbha*) came out.

Indian culture had the religious tradition in which the universe had a beginning. For centuries, theologians have been arguing about the interpretations of these accounts and about the meaning of a 'beginning' for the universe, together with such subtleties as whether time was created with the universe. For example, the fifth couplet of the *Nāsadiyasukta* (*tirascino bitato rasmiresam: adha svid asid upari svid asid, retodha asan mahimana asan svadhā avastat prayātih parastat*), according to Sāyana, refers to the suddenness of creation, which was developed in the twinkling of an eye, like the flash of light. It was so quick that it was doubtful whether the things in the central space were created first or those above or those below; in other words, creation took place simultaneously in all three portions of the universe. Sāyana tries to reconcile this with the received notion of creation in a series viz. that from atma came the *āk āsa*, and from the *ākāsa* the wind, from the wind the fire, etc; by saying that this was the order in which things were created, but the development of the world was like a flash of lightning, so that the series could not be distinguished. (Rg Veda, X, tr. by H H Wilson, Part-VI, p.437)

In the West 'when most people believed in an essentially static and unchanging universe' (*A Brief History of Time*,

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Stephen W Hawking, Bantam Books, (reprinted in 1998), p.9) 'the Hindu religion is the only one of the world's great faiths dedicated to the idea that the cosmos itself undergoes an immense, indeed an infinite, number of deaths and rebirths. It is the only religion in which the timescales correspond, no doubt by accident, to those of modern scientific cosmology. Its cycles run from our ordinary day and night to a day and night of Brahmā, 8.64 billion years long, longer than the age of the Earth or the Sun and about half the time since the Big Bang. (*Cosmos*, Carl Sagan, Ballantien Books, N Y, 1985 p.213)

In fact it was not by accident, as Carl Sagan has said, but the Indian seers had discovered the timescales by intuition: '*Hrdi pratisya kavayo manisa*', the poet-seers having meditated in their hearts had discovered it by their wisdom. The intuitively begotten mathematical numbers as stated in the *Siddhantas* regarding the beginning and end of the universe are of course baffling: According to the *Siddhānta Darpana*, half of the life span of Brahmā (fifty years) have already elapsed. At present it is the first day (*Śveta varāha kalpa*) of the second half of His life. Of this *kalpa* six out of fourteen *manvantaras* have already passed. Currently, the seventh *manvantara* (*vaivasvata*) is going on, of which twenty-seven *mahayugas* have already passed. Now it is the twenty-eighth *mahayuga* of which three *yugas* (*satya*, *tretā* and *dvāpara*) have already gone. At present second half of the kaliyuga (432,000 solar years) is going on and 4970 solar years have already passed since its inception up to the beginning of the composition of *Siddhānta Darpana*. As per calculation, the time from the beginning till the beginning of kali era comes to 1,972,944,000 earthly years (*S D*, 1/40–46). Almost all the Hindu *Siddhantas* including the *Surya Siddhānta* have adopted this timescale the antecedent of which is found, not in the Western astronomy as has been proposed by Prof. G R Kaye (*The Hindu Astronomy*, Cosmo Publication, 1981, p.61) but in the Atharva Veda:

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Śatam te ayutam hayanān dve yuge trini catvāri krnmah
Indrāgni visvedevaste'nu manyatāmahrniya ma nah.

A V, 8.2.21

i.e. to know the existence of the creation, add zeros up to ten thousand hundred after 432 (=4,320,000,000 or 4.32 billion years). This is equal to one day or night of Brahmā (8.64 billion/2).

Stephen Hawking argues:

> But in 1929, Edwin Hubble made the landmark observation that wherever you look, distant galaxies are rapidly moving away from us. In other words, the universe is expanding. This means that at earlier times objects would have been closer together. In fact, it seemed that there was a time, about ten or twenty thousand million years ago, when they were all at exactly the same place and when, therefore, the density of the universe was infinite. This discovery finally brought the question of the beginning of the universe into the realm of science. Hubble's observations suggested that there was a time, called the big bang, when the universe was infinitesimally small and infinitely dense. Under such conditions all the laws of science, and therefore all ability to predict the future would break down. If there were events earlier than this time, then they could not affect what happens at the present time. Their existence can be ignored because it would have no observational consequences. One may say that time had a beginning at the big bang, in the sense that earlier times simply would not be defined. It should be emphasised that this beginning in time is very different from those that had been considered previously. In an unchanging universe a beginning in time is something that has to be imposed by some being outside the universe, there is no physical necessity for a beginning. One can imagine that God created the universe at literally anytime in the past. On the other hand, if the Universe is expanding there may be

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> physical reasons why there had to be a beginning. One could still imagine that God created the universe at the instant of the big bang or even afterwards in just such a way as to make it look as though there had been a big bang, but it would be meaningless to suppose that it was created 'before' the big bang. An expanding universe doesn't preclude a creator, but it does place limits on when he might have carried out his Job.
>
> *A Brief History of Time*, pp.9–10

It may be noted that the word 'Brahmā' is derived from the root *brh* means to expand and thus suggesting the reality of the expanding universe. The word 'Visnu', according to Yāska, also means to expand. '*Atha yad visito bhavati tad visnurbhavatir Visnurvisaterva vyasnoterva*' (*Nirukta*, 12/19). It may be contended that the Eastern mystics had similar transcendental observations as Edwin Hubble had it by the aid of powerful telescope, so as to comprehend so definitely the birth and death of the universe.

As per the model provided by the *Surya Siddhānta* Chandrasekhar had also held the view that the universe is like two huge cauldrons one inverted upon the other (*Dvitaya Katāha*, *S D*, 18/21) and the metaphor signifies that the universe was known to be finite, just as modern cosmologists think it to be: 'The whole area of the earth's surfaçe is finite, and so too the whole volume of spherical space is finite.' (*The Expanding Universe*, Sir Arthur Eddington, CUP, 1987, reissued, p.35)

Carl Sagan says:

> Ten or twenty billion years ago, something happened – the Big Bang, the event that began our universe... All the matter and energy now in the universe was concentrated at extremely high density – a kind of cosmic egg, reminiscent of the creation myths of many nations – perhaps into a mathematical point with no dimension at all. In that titanic

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> cosmic explosion, the universe began an expansion which has never ceased... As space stretched, the matter and energy in the universe expanded with it and rapidly cooled. The radiation of the cosmic fireball, which, then as now, filled the universe, moved through the spectrum – from gamma rays to X-rays to ultraviolet light, through the rainbow colours of the visible spectrum, into the infrared and radio regions. The remnants of that fireball, the cosmic background radiation, emanating from all parts of the sky can be detected by radio telescopes to day.
>
> *Cosmos*, pp.200–201

So also Chandrasekhar had learnt that the beginning was an explosion and it was an explosion of light energy: '*Yattejah Ksubdhamayajanita...*' He had also learnt that there had been a 'phase transition' of the expansion of the universe the conception of which is similar to that of Alan Guth or Andrei Linde.

> *Utpadya Visnoh srjato dinādou*
> *graharksagolādikamabjayoneh.*
> *Trayamyugānām caranamtrayanca sardhamyatah*
> *Kalpamukhādayāsit.*
>
> S D, 1/45

As Chandrasekhar believed, in between the initial expansion (Visnu) and the subsequent creation (Brahmā) the universe must have taken time to be as we see it today and this period is 17,064,000 solar years. It consists of three *mahayugas*, three *yugas* and half of the *kali yuga*. During this 'phase transition', the celestial sphere of stars and planets was created by Brahmā. It may be compared with the historical interlude called 'inflation' which has been included in the preferred theory of the very early universe since 1980.

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Tatkāranam mahattattva rupi yah surya ucyate
Tato'nyah kathyate bhuyah kāryarupi svayambhubah
Ato dve rupyamarkasya brahmāndāntah pratiyate
Tatrādya syātmabhughasra kartutvam sambhabatyatah
Dvitiyasyāsurāmartya pitrmartya dinesatā
Vimbadevātmakatvacca Suryādinam dvirupata.

S D, 18/25.26.27

With reference to the origin of our solar system Chandrasekhar's interpreta tion of two suns as stated above resembles the description of the 'primordial fireball' given by Roger Penrose. As he says:

> Let us return to our quest for the origin of the second laws of thermodynamics (that the entropy of an isolated system increases with time or remains constant for a reversible system). We had tracked this down to the presence of diffuse gas from which the stars have condensed. What is this gas? Where did it come from? Mainly it is hydrogen, but there is also about 23 per cent helium (by mass) and small quantities of other materials. According to standard theory, this gas was just spewed out as a result of the explosion which created the universe: the big bang. However it is important that we do not think of this as an ordinary explosion of the familiar kind, where material is ejected from some central point into a pre-existing space Here the space itself is 'enacted' by the explosion, and there is, or was, no central point! ...The material blasted out in the big bang is simply spread out uniformly over the 'entire' spatial universe! ...This picture underlies the theory of the 'hot big bang' referred to as the 'standard model'. In this theory, the universe, moments after its creation, was in an extremely hot thermal state – the primordial fireball. Detailed calculations have been performed concerning the nature and proportions of the initial constituents of this fireball, and how these constituents changed as the fireball (which was the entire universe) expanded and cooled... The final implications of

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these calculations are that, spreading out in a uniform way throughout the entire universe would be many photons (i.e. light), electrons and protons (the two constituents of hydrogen), some α-particles (the nuclei of helium), still smaller numbers of deuterons (the nuclei of deuterium, a heavy isotope of hydrogen), and traces of other kinds of nuclei – with perhaps also large numbers of 'invisible' particles such as neutrinos, that would barely make their presence known. The material constituents (mainly protons and neutrons) would combine together to produce the gas from which stars are formed (largely hydrogen) at about 10^8 years after the big bang.

Stars would not be formed at once. However, after some further expansion and cooling of the gas, concentrations of this gas in certain regions would be needed in order that local gravitational effects can begin to overcome the overall expansion. Here we run into the unresolved and controversial issue of how galaxies are actually formed, and of what initial irregularities must be present for galaxy formation to be possible. I do not wish to enter into the dispute here. Let us just accept that some kind of irregularities in the initial gas distribution must have been present, and that somehow the right kind of gravitational clumping was initiated so that galaxies could form, with their hundreds of thousands of millions of constituent stars.

The Emperor's New Mind, Oxford, 1999, pp.423–425

Origin of the star out of the primordial fireball as stated by Penrose elucidates, more clearly than any traditional commentary, the significance of the second sun coming out of the *hiranyagarbha* or the Vedic fireball which has been revered in the *Siddhāntas* through all ages. In this context the interpretation of the fifth couplet of the *Nāsadiyasukta* in the light of the Nebular Hypothesis may be recollected as a link:

Tirascino vitato rasmiresām adhahsvidāsiduparisvidāsit
Retodha āsan mahimāna āsan svadhā avastāt prayātih parastāt.

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According to Dr P V Vartaka and Dr A S Ramanathan (nuclear scientist) this Vedic hymn suggests:

> Strands or rays scattered out; were they oblique or downward? or upward? They became shedders of seeds and mighty. Those who tried to keep themselves aloof remained small or those who surrendered themselves became inferior, while those who tried hard became superior. Rasmi means strands of rays. *Abhu* (gas drops) emitted light rays in all directions. They also scattered matter in strands which are seen in spiral nebulae. Our galaxy also has two spiral 'arms'. In space there is no real direction, hence up, down or oblique has no meaning. Thus the strands were in all possible direction, or in spiral shape with changing directions. Out of the matter in the strands some lump came together to become seed shedders. Those which remained aloof remained small – named *svadhā*. Some bodies surrendered themselves to others, these are also *svadhā*. Other bodies absorbed more and more matter and smaller bodies by gravitational attraction and became enormous. These are *Prayātih*. This is similar to Nebular Hypothesis of Laplace, modified by Weizasackr.
>
> S D, A K Upadhyaya (ed.), vol. II, pp.823–824

It is affirmed, as in S Weinberg's *The First Three Minutes: A Modern View of the Origin of the Universe* (Andre Deutsch, London, 1977), that calculations can be reliably performed for describing a state of the universe which was so different from that of our present era and the physics on which these calculations are based is not controversial so long as we do not ask for what happened 'before' about the first 10^{-4} of a second after creation. And in the face of lacking in such detailed calculations the ancient Indian theory of creation has been denounced by the Western scientists. However, we should remember that 'calculation' does not always mean formal mathematical or physical calculations only. There is another standpoint which is known as 'intuitionism'. The

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roots of 'intuitionism' can be traced back to antiquity but it was initiated in 1924, by the Dutch mathematician L E J Brouwer as an alternative response – distinct from that of formalism. But doubtless in *Siddhāntas* as in the Veda, there are theories of the origin of the universe which are equally convincing so that one can certainly conclude, like Eddington: 'Since I cannot avoid introducing this question of a beginning, it has seemed to me that the most satisfactory theory would be one which made the beginning "not too unaesthetically abrupt"' (*The Expanding Universe*, p.56). Perhaps Chandrasekhar had found aesthetic reason, like those of Eddington, to accept a gradual beginning and to condemn the theory of Bhaskara who had not accepted a creative interlude for the Universe (*Sristikalasya ca tyaga matkrtva kalpavaktrata*, *S D*, 21/41). Or else he thought, like Gödel, that intuition by which we can 'see' truths of mathematics and science, was a tool that would one day be valued just as formally and reverently as logic itself. Gödel said:

> I do not see any reason why we should have less confidence in this kind of perception, i.e., in mathematical intuition, than in sense perception, which induces us to build up physical theories and to expect that future sense perceptions will agree with them and, moreover, to believe that a question not decidable now has meaning and may be decided in the future.
>
> K Gödel, 'What is Cantor's Continuum Problem?' *Philosophy of Mathematics*, P Benacerraf and H Putnam (ed.), Prentice Hall, 1964, p.483

According to Eddington the first hint of an 'expanding universe' is contained in a paper published in November 1917 by Prof. W de Sitter, two years after the publication of Einstein's general theory of relativity. But in India it was known since the Vedic age. The phenomenon of the expanding universe has been described in a number of

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compositions such as: 'The maker of the senses, resolute in mind, engendered the water, (and then) these two (heaven and earth) floating (on the waters), when those ancient boundaries were fixed, then the heaven and earth were expanded' (*R V*, X.82/1, Wilson). 'Having eyes everywhere and having a face everywhere, having arms everywhere and having feet everywhere he traverses (heaven) with his arms, (earth) with his swift moving (feet), and exists a god without companion generating heaven and earth' (*R V*, X.81/3, Wilson). The Vedic seers had discovered the most appropriate metaphor for the expanding universe: 'as soon as born, the embryo devours the parents' (*R V*, 79/4) and in comparison with the Vedic metaphor, the metaphor of the 'inflated balloon' of the modern scientists appears less congruous. It is admitted by Fritjof Capra that this idea of a periodically expanding and contracting universe, which involves a scale of time and space of vast proportions, has arisen not only in modern cosmology, but also in ancient Indian mythology. Experiencing the universe as an organic and rhythmically moving cosmo s, the Hindus were able to develop evolutionary cosmologies which come very close to our modern scientific models. (*The Tao of Physics* , Flamingo, 1991, pp.219–22)

The remarkable feature of Indian astronomy was that though the astronomers were all aware of the phenomena, they were least bothered by that. Perhaps they were nevertheless aware of the net result of the expansion of the universe. 'The result', as has been deduced by Sir Arthur Eddington, 'is that only the intergalactic distances expand. The galaxies themselves are unaffected and all lesser systems – star clusters, stars, human observers and their apparatus, atoms – are entirely free from expansion. Although the cosmical repulsion or expansive tendency is present in all these smaller systems, it is checked by much larger forces and no expansion occurs' (*The Expanding Universe*, pp.88–

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89). Therefore Chandrasekhar, like all other ancient Indian astronomers, has unequivocally accepted the lines of the *Surya Siddhānta* in which the phenomenon of expansion has been personified as *Aniruddha* meaning the open universe ever expanding (*S D*, 18/ 5–6). He has also mentioned that the sphere of earth increases in all directions by one *yojana* in one *kalpa* (*S D*, 18/94) in order to show the expansive tendency present in a smaller system like this earth.

But one of the starkest questions posed by the Big Bang picture of the expanding universe is whether our universe is going to continue expanding for ever or whether it is doomed to collapse back upon itself towards a 'Big Crunch' at sometime in the future, and it is worth knowing what our ancient astronomer-poets had fancied to think about the fate of our universe or at least of the visible part of the u niverse. There were elliptically divergent opinions in earlier times too, as of today, but surprisingly almost all of them were unanimous with respect to the question of deluge of the universe, as they were sure of a beginning. With conviction Chandrasekhar has argued in favour of this ancient hypothesis.

Itidviso brahmadine grahabhramah prapuryate
tannidhanena tatksayah
Idam matam meyadudi rtam budhairgrahaksayah
pratyahameva kaiscan
Svayambhuvasardhamadarsanam bhuvobhaveditidam
na vicāracārume
Bhuvāsamam prākrtikelaye ksayomayocyate
bhagraha loka raksinam.

S D, 1/49–50

Baddhirbidheralmi bhuvah samantāt
Syādyojanam bhuvababhutapurbe
Brahmelaye yojanamātra brddher nāsobhuvah
prākrtike khilāyah
Dine dine yanmriyatehibhutairdainandinam

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tam pralayam badanti
Brāhmyam layam brahmādināntakāle
bhutaniyad Brahmā tanumbrajanti
Brahmātyayeyat prakrtim prayānti
sarbānyatah prakrtikam krtindrāh
Linanyatah karma putāntaratvat prthakkriyante prakrterbikāraih.

S D, 18/ 148–150

The essence of these lines, as has been rendered by Carl Sagan, is the deep and appealing notion that the universe is but the dream of the God who, after a hundred Brahmā years, dissolves himself into a dreamless sleep. The universe dissolves with him – until, after another Brahmā century, he stirs, recomposes himself and begins again to dream the great cosmic dream. Meanwhile, elsewhere, there are an infinite number of other universes, each with its own god dreaming the cosmic dream. (*Cosmos*, p.214)

Carl Sagan has further explained that: 'In India there are many gods, and each god has many manifestations. The Chola bronzes, cast in the eleventh century, include several different incarnations of the god Shiva. The most elegant and sublime of these is a representation of the creation of the universe at the beginning of each cosmic cycle, a motif known as the cosmic dance of Shiva. The God, called in this manifestation Nataraja, the dance king, has four hands. In the upper right hand is a drum whose sound is the sound of creation. In the upper left hand is a tongue of flame, a reminder that the universe, now newly created, will billions of years from now be utterly destroyed.' (*Cosmos*, p.214)

These profound and lovely images are, according to him, likely to be imagined as a kind of premonition of modern astronomical ideas. Very likely the universe has been expanding since the Big Bang, but it is by no means clear that it will continue to expand forever. The expansion may gradually slow, stop, and reverse itself. If there is less than a

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certain critical amount of matter in the universe, the gravitation of the receding galaxies will be sufficient to stop the expansion, and the universe will run away forever. But if there is more matter than we can see – hidden away in black holes, say, or in hot but invisible gas between the galaxies – the universe will hold together gravitationally and partake of a very Indian succession of cycles, expansion followed by contraction, universe upon universe, cosmos without end. If we live in such an oscillating universe, the Big Bang is not the creation of the cosmos but merely the end of the previous cycle, the destruction of the last incarnation of the cosmos. (*Cosmos*, pp.214–215)

Now the question arises how the ancient astronomer-poets could be so sure of a Big Crunch? While our most modern astronomers are endlessly worried by the 'ifs and buts' of the problem, how come our ancient astronomers arrived at the conclusion? Particularly after the Kafkesque aspect of Gödel's work and character is expressed in his famous Incompleteness Theorem, as Rudy Rucker says, scientists are thus left in a position somewhat like Kafka in *The Castle*. Endlessly, we hurry up and down corridors, meeting people, knocking on doors, conducting our investigations. But the ultimate success will never be ours. Nowhere in the castle of science is there a final exit to the absolute truth. (*Infinity and the Mind*, Harvester, Sussex, 1982, p.165)

Equally, the uncertainty principle of Heisenberg has profound implications for the way in which we view the world. The principle states that one certainly cannot predict future events exactly if one cannot even measure the present state of the universe precisely. Then what prompted the Hindu astronomers to decide on the fate of the universe? Stephen Hawking argues that although the uncertainty principle places limitations on the accuracy of all our predictions, it may at the same time remove the fundamental

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unpredictability that occurs at a space–time singularity (i.e. the point in space–time at which the space–time curvature becomes infinite as the general theory of relativity predicts and that is the point in the universe where the theory itself breaks down). (*A Brief History of Time*, p.120)

Einstein's general theory of relativity, on its own, predicted that space–time began at the big bang singularity and would come to an end either at the big crunch singularity (if the whole universe collapsed), or at a singularity inside a black hole (if a local region, such as a star were to collapse). Any matter that fell into the hole would be destroyed at the singularity, and only the gravitational effect of its mass would continue to be felt outside. On the other hand when quantum effects were taken into account, it seemed that the mass or energy of the matter would eventually be returned to the rest of the universe, and that the black hole, along with any singularity inside it, would evaporate away and finally disappear. Detection of black holes (i.e. a region of space–time from which nothing, not even light can escape, because gravity is so strong) in systems like Cygnus X-I in our galaxy and in two neighbouring galaxies called the Magellanic clouds have substantially supported the hypothesis of deluge as proposed by modern scientists. Had our ancient astronomers been blessed with such information or findings so as to expound a similar hypothesis?

It may be construed that the ancient astronomers had deducted it from their observations of the visible portion of the universe, however small it might be, and attributed it to the whole context of the universe. From this observable part of this universe they had learnt that the arrow of time is irreversible and as the universe had been thought to have a beginning, it must be led, in time, to an end. Chandrasekhar, like his forerunners, has simply indicated it. *Kālenaivacasrjyante sa eva grasate punah* (*S D*, 22/5), Western views of the nature

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of time might have changed over the years according to the theory of relativity, second law of thermodynamics, singularity theorem, etc. But the basic concept of cosmological arrow of time as had been evinced by the Indian astronomer-poets has rather been strengthened by these new theories. (For details, *Cosmology and the Arrow of Time* by Roger Penrose, *The Emperor's New Mind*, pp.391–449 or *The Arrow of Time* by Stephen Hawking, *A Brief History of Time*, pp.151–161 may be referred)

'The great deluge' at the end of a *kalpa* of Brahmā can be obviously foreseen only from proofs of the inevitability of death of stars as it seems not to be of mere mythological fantasm. If the death of a star were unheard of ever in the past, it could not have been contended that the entire celestial sphere is likely to be dissolved. But so far as ancient Indian astronomy is concerned, no such account is available which can contest the modern concept of black holes or white dwarfs i.e. the basis on which dying of stars could be ascertained. Surprisingly, Samanta Chandrasekhar has given a hint, though very fuzzy, to this effect:

Durādhikyād yad himarajo bāspasanghātajāta
Tadrgjyotih ksatiritimatirbhāt: bhānām tateste
Tat khetānām vividhasaranibhrājatām vimbatulya
Stārah kim tatsama rucibhrtobhrantikrptamhimādyam
Nediyastvād yadikujamukhah susthirālokavanta
Stārā durascalahimamukhairābrtāh kampabatyah
Drsyante tat kvaciditi ghanai scāditāh santuluptāh
Svajvālānām sphuranakaranam siddhamagneribātah.

S D, 17/144–145

In order to explain the Olbers' Paradox it is stated that the darkness of the night is not being removed in spite of the presence of numerous stars because their light is being feebled by the distance and absorption. With a view to

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raising his objection Chandrasekhar asks how can light ever be sucked? (*Tejasah syatkatham panam drstibhogotra kebalah*, *S D*, 18/34). The nature of light is such that who or what sucks it becomes radiant. It is further argued that it is being absorbed by vapour and snow particles. Then eventually stars would be dying in the vast encircling coldness as fire is extinguished by snowfall! He asks: Is the flickering of stars' light a symptom of their collapsing condition? Has the death of a star ever been seen? Then he concludes that stars can never look as bright as the planets within the orb of sunlight. Chandrasekhar has abandoned the question as it is, but nevertheless, he was inquisitive of why the death of a star is not visible. This however had not sh aken his belief in the inevitability of the death of a star. Prior to Chandrasekhar, a Cambridge don, John Michell, had of course written a paper in 1783 in the *Philosophical Transactions of the Royal Society of London* in which he had pointed out that a star that was sufficiently massive and compact would have such a strong gravitational field that light could not escape; any light emitted from the surface of the star would be sucked by its own gravitational attraction before it could get very far. Michell had suggested that there might be a large number of stars like this. We would not be able to see them because the light from them would not reach us. We would still feel their gravitational attraction. Such objects are nowadays called black holes. (*A Brief History of Time*, p.86)

Which point of the Euclidean three-dimensional space of physical experience at one time is the 'same' point of our Euclidean three-dimensional space at another time? This question has led the post-Einsteinian scientists to the belief that we must have a completely 'new' Euclidean space for each moment of time. The way to make sense of this is to consider a four-dimensional space–time continuum of physical reality. Einstein remarks:

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> Hitherto it had been silently assumed that the four-dimensional continuum of events could be split up into time and space in an objective manner, i.e. that an absolute significance attached to the 'now' in the world of events. With the discovery of the relativity of simultaneity, spa ce and time merged in a single continuum in the same way as the three dimensions of space had been before. Physical space was thus increased to a four-dimensional space which also included the dimension of time. The four-dimensional space of the Special Theory of Relativity is just as rigid and absolute as Newton's space.
>
> *Essays in Science*, A Mentmore Book, 1958, p.68

Though it is impossible to imagine a four-dimensional space, Stephen Hawking finds it hard enough to visualise three-dimensional space (*A Brief History of Time*, p.25). Could there be a fourth physical dimension? Carl Sagan answers:

> Let us take our three dimensional cube and carry it, at right angles to itself, through a fourth physical dimension: not left-right, not forward-back, not up-down, but simultaneously at right angles to all those directions. I cannot show you what direction that is, but I can imagine it to exist. In such a case, we would have generated a four-dimensional hyper-cube, also called a tesseract. I cannot show you a tesseract, because we are trapped in three dimensions. But what I can show you is the shadow in three dimensions of a tesseract. It resembles two nested cubes, all the vertices connected by lines. But for a real tesseract, in four dimensions, all the angles would be right angles.
>
> *Cosmos*, p.219

And it is concluded that increasing all dimensions by one, we have the situation that may apply to us; the universe as a four-dimensional hyper-sphere with no centre and no edge, and nothing beyond.

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As has been said by Eddington, the difference between the mathematician and the non-mathematician is that the former can picture things in four dimensions. But Eddington also has added that although the mathematician visualises four dimensions, his picture is 'wrong' in essential particulars – at least Eddington's is. He sees the spherical universe like a bubble in four dimensions; length, breadth, and thickness, all lie in the skin of the bubble. Can the rotation of this bubble be pictured? Of course it can be, if an axis is fixed on one direction in the four dimensions and the other three dimensions can be seen whirling round it. Perhaps more than two dimensions can never be actually seen, but thought would flit rapidly from one pair to another, so that all three would seem to be hard at it. Can it be pictured like this? By analysis it is known that a bubble in four-dimensions does not rotate that way at all. Three dimensions cannot spin round a fourth. They must rotate two round two; that is to say, the bubble does not rotate about a line axis but about a plane. And it cannot be visualised.

While depicting the curvature of space, Eddington had suggested that indeed it was only in simple and symmetrical conditions that a fourth dimension sufficed and the general picture required six dimensions (or, when they extended the same ideas from space to space–time, ten dimensions were needed) (*The Expanding Universe*, p.31). To add to our discomfort, the superstring theory opened another Pandora's box of possibilities. Superstring theories are the only current theories of physics which do not lead to internal contradictions or to predictions that measurable quantities have infinite values when gravity is merged with the other forces of Nature. Yet these consistent theories of the fundamental forces of Nature appear to require the universe to have many more dimensions of space than the three that we habitually experience. The original string theories required the universe to have either nine or

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twenty-five dimensions of space! (*Superstring*, Davies Brown (ed.), CUP, 1988)

Putting the mystery of the selective inflation process to one side, John D Barrow points out that we are confronted with a major uncertainty. The true Constants of Nature, and the forms of the laws of nature, are really framed in nine or twenty-five, or some other number of dimensions of space. A complicated physical process leaves only three dimensions expanding to constitute the astronomical universe we see around us. The quantities we call the constants of physics are just three-dimensional shadows thrown by the true constants, which live in the full number of dimensions. Remarkably, if the extra dimensions exist and change their size by expanding as our three-dimensional part of the universe does, this would be revealed by a change in our 'constants' of Nature at exactly the same rate. The possibility that out Universe contains many more than three dimensions of space, trapped at the Planck scale of size, means that our access to the overall structure of the universe might be limited even more dramatically than we have previously suspected. (*Impossibility*, p.185)

In the above discussion one thing should be taken into reconsideration. The theory of relativity speaks of the four-dimensional space of the universe. But it is not exactly the four-dimensional space, in which three dimensions are of space and one of time, that is, to represent graphically what the theory of relativity refers to as space–time continuum. As Sir James Jeans says:

> For a one eyed man or one viewing objects, so remote that his binocular vision conveys no idea of distance perceptual space is two-dimensional at least so long as no sense other than seeing is involved. Thus ancients located the fixed stars on the two-dimensional surface of a sphere. As soon as near objects are viewed by a normal man, so that

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> binocular is employed, or as soon as objects are seen to move one behind another, or as soon as senses other than seeing are employed, a third dimension of perceptual space instantly springs into being.
>
> *Physics and Philosophy*, 1948, p.67, cf.
> *A Comparative Study of the Concepts of Space and Time*,
> Dr K K Mandal, Chowkhamba, 1968, p.163

'The subtle change which makes the sight see in a sort of fourth dimension' has been characterised by Sri Aurobindo as the attainment of the supramental sense through 'the synthesis of Yoga'. He says:

> As soon as the sight, for example, is altered under the influence of the supramental seeing, the eye gets a new and transfigured vision of things and of the world around us. Its sight acquires an extraordinary totality and an immediate and embracing precision in which the whole and every detail stand out at once in the complete harmony and vividness of the significances meant by Nature in the object and its realisation of the idea in form, executed in a triumph of substantial being.

He further compares:

> It is as if the eye of the poet and artist had replaced the vague or trivial unseeing normal vision, but singularly spiritualised and glorified, as if indeed it were the sight of the supreme divine Poet and Artist in which we were participating and there were given to us the full seeing of his truth and intention in his design of the universe and of each thing in the universe.
>
> *The Synthesis of Yoga*, 1984, Sri Aurobindo Ashram, p.837

Fritjof Capra maintains that the intuition of Eastern mysticism is one of the main reasons why its views of nature seem to correspond, in general, much better to modern

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scientific views than do those of most Greek philosophers. Greek natural philosophy was, on the whole, essentially static and largely based on geometrical considerations. It was, one could say, extremely 'non-relativistic', and its strong influence on Western thought may well be one of the reasons why we have such great conceptual difficulties with relativistic models in modern physics. The Eastern philosophies on the other hand, are 'space–time' philosophies, and thus their intuition often comes very close to the views of nature implied by our modern relativistic theories (*The Tao of Physics*, p.190). In fact, not only Indian philosophy but also Indian astronomy deals with space and time in a similar vein. The space–time continuum as has been mentioned in the *Brhadāranyakopanisad* (III, 8.4) – '*Sahovaca, yadurdhvam, Gargi, divah, yad avak prthwiyah yad antara dyāvāprthivi me, yad bhutani ca bhavasca ceti bhavisyasca cetiacaksate ākāse tadotam ca protam ceti*' (Yājnavalkya says to Gargi that what people call the past, the present, and the future are woven like warp and woof across the space). It, clearly refers to a series where time and space are mingled like that of the relativistic space–time and the Indian astronomy also possesses the same type of vision:

Trtyādipralayāntesu janyakālesu vatsarah
Pradhāna bhuto' vayavo khāngairyukto' yanādibhih.

(S D, 22/16)

Kālākhyasya bibhoridam bhagabato nityasya rupāntaram
Jyotiscakramitibrbantyabayavā strtyādayo' syetyapi.

(S D, 1/23)

Chandrasekhar's above lines of verses speak of the embodiment of time in the form of material bodies studded in the sky. The cosmic sphere itself emanates as time from the eternity and therefore time cannot be separated from the space, nor space from time. Apart from this fourth dimension of space Indian astronomers had nevertheless

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apprehended extra dimensions of the universe as string theorists propose today. The Indian astronomy as well as the Puranas presuppose fourteen dimensions of the universe (*caturdasa bhuanani*) such as: *Bhu*, *Bhuvah*, *Sva*, *Jana*, *Tapa Satya* and *Maha* (seven *lokas*) with *Atala*, *Vitala*, *Sutala*, *Talatala*, *Mahatala*, *Rasatala* and *Patala* (seven *talas*) (*Kurma Purana*, Ch. 44, *Visnu Purana*, Ch. 11.7, *Brahmānda Purana* – 1.7 23–24/1.5, 115, *Vāyu Purana*, 7.37/8.24, etc. The *talas* have been named differently in some of the *Puranas*. The names mentioned here are from *Bhagavata Purana*, 5.24, 7–31). That these are dimensions of the universe is clear from the statement: *Brahmāndānanta susiram yatrevam bhur bhuvadikam* (*S D*, 18/21) (These are well within the empty womb of the universe). Chandrasekhar conjectures that the *pātālalokas* lie engraved into the world: '*Patalalokah prthiviputani*' (*S D*, 18/119) and:

Bhurlokākhyo daksine vyaksadesāt
Tasmāt saumyoyam bhuvasvasca meru
Lavya punyaistair maho's majjano'to
Lavyo' nalpaistai stapah satyamantyah.

S D, 18/139

Region near equator, i.e. the place of zero latitude is *Bhuloka*, to the north of equator lies *Bhuvah*. *Meru* is *svarloka*. Above that lie *Maha*, *Jana*, *Tapa*, and *Satya*.

We may wonder what, in spite of Chandrasekhar's conviction about the sphericality of the earth and the universe, prompted him to make his calculations Euclidean! The axiom on which his omission of space– time curvature rest is not to be despised in this highly sophisticated age of cosmology. He says:

Samoyatahsyātparidheh satāmsa
prthvicaprthvinitarāmtaniyān

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narasca tatprstha gatasyakrtsnā
sameva tasya prativātyatahsā.

S D, 17/20

He proposes that one-hundredth part of any circumference is too little a curvature to be accounted for. The bigger the circumference, the more flat it becomes. With respect to human beings the earth is too big, and the space is even bigger, to be reckoned with curvature. According to Professor E A Milne, there is no need to regard space as non-Euclidean and that the geometry we adopt can be decided entirely by motives of convenience (*Relativity Gravitation and World Structure*, Oxford, 1935). Curved spaces, which are locally Euclidean are called Riemannian manifolds named after Bernhard Riemann (1826–1866). In the same way Minkowski's geometry accords flat space–time called Lorentzian manifolds allowing a little curviness to space–time due to the presence of gravity. (*The Emperor's New Mind*, Penrose, p.268)

It is amazing that our ancient astronomers were less fascinated by questions about the constants of physics, but still successfully carried on their business. Eddington (*New Pathways in Science*, p.230) gives the following list of the primitive constants of physics: the charge of an electron (e), the mass of an electron (m), the mass of a proton (M), Planck's constant (h), the velocity of light (c), the constant of gravitation (G), and the cosmical constant (λ). Sir William McCrea says:

> Nowadays probably most physicists believe that they ought to be able to do something about the constants of Nature – perhaps to discover relations between them and so to reduce the number of 'independent' constants – perhaps to relate the behaviour of the whole cosmos to the existence and values of the constants – perhaps to discover that some

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> of the constants are not constant (but were it possible to assert that some particular 'constant' varies in a particular way then the coefficients in the formula describing such behaviour would presumably have to be constant) – perhaps even to predict the existence and values of all such constants. At the present time discussions of such matters tend to be linked with consideration of the anthropic principle in its various forms.
>
> Foreword to Eddington's, *The Expanding Universe*, CUP, 1986, p.xxiii

For instance, the revolutionary suggestion made by Einstein in his general theory of relativity (1915) may be taken into consideration. According to this theory 'gravity' is not a force like other forces, but is a consequence of the fact that space–time is not flat, as had been previously assumed; it is curved, or 'warped' by the distribution of mass and energy in it. Bodies like the earth are not made to move on curved orbits by a force called 'gravity'; instead they follow the nearest thing to a straight path in a curved space, which is called a geodesic. In general relativity, bodies always follow straight lines in four-dimensional space–time, but they nevertheless appear to us to move along curved paths in our three-dimensional space. (*A Brief History of Time*, Hawking, pp.32–33)

Newtonian theory of gravity stated that objects attracted each other with a force that depended on the distance between them. This meant that if one moved one of the objects, the force on the other one would change instantaneously. Or in other words, gravitational effects should travel with infinite velocity, instead of at or below the speed of light, as the special theory of relativity required. This inconsistency made him to think over a new theory of gravity. But the striking resemblance of Chandrasekhar's rejection of Newtonian gravitational force with Einstein's compel us to reinvent Chandrasekhar:

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Yathāryamā krsta budhadayo grahā
Bhramatsvadehāh pariyanti santatam
Svakaksayā pakrama yuktayā tathā
Pathātmanahksmā bhramatiti te pratha
Nasyādgatih saktimrte khilasya
Sākarsabiksepabasā dvidhācet
Kendrābhikarsinyavidhā tadādyā
Kendrāpasārinya parocyatesā
Parānu bāhulya samudbhabādyā
Drstvā gurutvābagamāddharitryām
Tatrāpatad golakapindasāsvatparibhramo
'smabhira laksinaiva'
Praksiptalostre ksanato' parasyam
Saktauca gola bhrama sambhabona
Samaksitau ksepabalenagolah
Kintviksateyān paribartamāna.

S D, 17/48–51

You assert that planets like Buddha (Mercury) move in their orbits in addition to moving round their axis due to the gravitational force of the Sun. So also the Earth is. You also argue that a body moves only by force which is of two types, i.e., centripetal and centrifugal. In that case both types of forces ought to be in Earth also, because Earth is a formation of huge amount of atoms from which force initially emanates. But we do not see any resultant effect of the centrifugal force of the earth. We never see a stone rotating on its axis even for a moment when it is thrown up. But on the surface of the earth a spherical object rolls on instead of rotating on its axis when it is thrown.

(Chandrasekhar, however, says that as everything made of atoms are being attracted by the earth's attracting force, it clearly shows that all other forces are overpowered by its own power of attraction.) (*S D*, 17/12)

Similarly, the mathematical device known as cosmological constant, which had been introduced by Einstein to give

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space–time an in-built tendency to expand, had been rejected later on by himself with the remark that it was the biggest mistake of his life (*A Brief History of Time*, Hawking, p.159). Besides these, the velocity of light looks like another intriguing question. The theory of relativity states that the velocity of light is the top limiting velocity in the universe. Any displacement of mass and energy and any transmission of interaction of forces can occur only at speeds not exceeding the speed of light. A detailed analysis of the light received from distant galaxies has shown that:

> ...the whole swarm of galaxies expands and that it does so in a well orchestrated way; the recession velocity of any galaxy we observe is proportional to the galaxy's distance. The more distant the galaxy, the faster it moves away from us; at double the distance, the recession velocity will also double. This is true not only for distances measured from our galaxy, but applies to any point of reference. Whichever galaxy you happen to be in, you will observe the other galaxies rushing away from you; nearby galaxies at several thousand miles per second, farther ones at higher speeds and the farthest at velocities approaching the speed of light. The light from galaxies beyond that distance will never reach us, because they move away from us faster than the speed of light. Their light is in the words of Sir Arthur Eddington like a runner on an expanding track with the winning post receding faster than he can run.
>
> *The Tao of Physics*, Capra, p.217

This situation looks paradoxical to the cosmic speed limit. Therefore, it can be suggested in principle that along with the world of velocities that are lower than the velocity of light (tardyon universe) there exists another world in which the velocity of light is not the upper but the lower limit of possible speeds (tachyon universe). The finiteness of the speed of light partitions the universe into parts which are

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out of causal contact with each other. We can gather information about the universe only from the region within the horizon that the speed of light defines for us. Again we see the very real possibility of a universe in which 'constants' of nature differ from place to place.

As the implications of the scenario of a chaotic inflationary model of the universe, put forward by Linde and certified by Stephen Hawking as a better model (*A Brief History of Time*, p.139) have been explored, John D Barrow concludes:

> ...it has emerged that all sorts of other properties of the universe could vary from one inflated bubble to the next. Some of the quantities that we call the 'constants of physics' – the strength of gravity, the masses of elementary particles, or even the number of dimension of space – could vary from bubble to bubble. All the astronomical observations that we have made show the values of constants of Nature to be the same from place to place within our visible horizon to huge precision (better than one part in 10^{15} in some cases). This is exactly what we would expect to find, even if those constants could vary all over the universe. When any tiny region inflated, then all observers who eventually evolved within it would find the constants of Nature to be the same to very high precision because they derived from the same inflationary patch long ago. This picture greatly extends our picture of the possible spatial complexity of the Universe. Unfortunately, it puts that complexity beyond the reach of science. One day, astronomers in the far future may see the signs of the nearest bubble coming into view. But they will never know how much more lies beyond.
>
> *Impossibility*, p.170

Likewise, our ancient astronomers and even Chandrasekhar knew that the universe was not only bigger than they knew, it was bigger than they could ever know:

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Tripādamamrtam guhyam pādoyam prakato' bhavat.

S D, 18/12

Of the immortal Brahmā at best only one quarter could be apparently seen, the remaining three quarters are always hidden.

Therefore, Chandrasekhar, conceding to the limitation imposed by the universe, has said:

Sarvāscaryamahambudherbhagavatah sthule vibhandhāmani
Kridāndānnganah sphurantikatidhā no vetti vedhā api
Tasmād veda purāna varnita jaganmānādikam no mrsam
Kintvasmadvasate bhurbo' ntika jusāmesā sthitirjyotisām.

S D, 19/123

God is the limitless ocean of wonders. There are infinitesimally small innumerable worlds within his enormous body – even Lord Brahmā cannot fathom. Hence the picture of universe, as described in the Vedas and Puranas and the measurements given therein, though cannot be altogether false, still I shall limit my discussion only to the part of the universe which is visible from this earth.

The atomic constitution of matter was well known in India from quite early times. The *Vaisesika* and *Nyāya* schools of thought considered it in great detail. According to Prof. Krishnaji the *Pilupaka* process in the *Nyāya-Vaisesika* literature is similar to Dalton's atomic theory (*Science and Technology in the Vedas*, Nag Publishers, Delhi, 1995, p.28). So it is no wonder that Chandrasekhar would have known that the atoms are the ultimate particles of the universe – a view which was held until the early years of this century. The subatomic particles like electron, neutron, proton, or quark were unheard of. So Chandrasekhar's contention was not gross when he told that atoms were the truly elementary

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particles, the basic building blocks from which everything was made: *Parānu bahulya samudbhavadya.* (*S D*, 17/50)

More recently we have learnt that using wave/particle duality discussed in quantum mechanics, everything in the universe including light and gravity, can be described in terms of particles. These particles have a property called spin. All the known particles in the universe can be divided into two groups: particles of spin ½, which make up the matter in the universe, and particles of spin 0, 1, and 2 which give rise to forces between the matter particles (*A Brief History of Time*, pp.70–72). This broad classification of particles into two groups such as matter particles and force-carrying particles seems to be nothing new when we see Chandrasekhar's traditional classification:

> *Srasturyāyāsarirendriya visayamayi*
> *bhutasrstih purāsi*
> *Uttadvijamdvidhāntarbahirabhavaditah*
> *pancakam mandalānām*
> *Bahyam brahmāndabhāndavrati rudarasamā*
> *kāramantah khavāyoh*
> *Vrimbadvandvam ravindu ksitaya iha*
> *mahastoyabhumandalāni.*
>
> S D, 19/1

> The elementary matter which remained after the desolation of all sensual and physical manifestations of the previous universe was decided by the Creator into two types of seed particles, i.e., outer seed and inner seed. Outer seed particles formed the cover of the cosmic egg and out of the inner seed the in-dwelling sky, the air, the sun, the moon, and the earth were formed.

A philosopher once said, as has been quoted by the outstanding contemporary American physicist Richard Feynman:

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It is necessary for the very existence of science that the same conditions always produce the same results. But Feynman has gone on to admit that 'well, they do not. Even if you set up the circumstances with the same conditions every time, still you cannot predict behind which hole you will see the electron. Yet science goes on in spite of it although the same conditions do not always produce the same results. In fact it is necessary for the very existence of science that minds exist which do not allow that nature must satisfy some preconceived conditions.

The Character of Physical Law, R Feynman,
London, 1965, pp 147–148

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Chapter VII

O TEMPORA! O MORES!

(O the times! O the manners! – Cicero)

Dvādasa pradhayascakramekam trininābhyāni ka u ta tciketa
Tasmin tsākam trinsatā na sankaro rpitāh sastirna calācalasat.

R V, 1/164/48

The fellies are twelve; the wheel is one; three are the axles but who knows it? Within it are collected 360 (spokes), which are, as it were, moveable and immovable.

Dvādasāram nahi tajjarāya varvarticakram paridyāmrtasya
Aputrā agne mithunāso atra saptasatam vimsatisca tasthuh.

R V, 1/164/11

The twelve-spoked wheel of the tree (sun) revolves round the heavens, and never (tends) to decay: seven hundred and twenty children in pairs, Agni, abide in it.

The endowment to comprehend time as a dimension – to look back in order to recollect, and to look forward in order to estimate – is one of the principal characteristics in which human beings display their identity as members of a distinct species of primate. But a significant stage in the perception of time came when people began to regard it as an abstract dimension rather than as part of a cycle. A sign that they were beginning to do so came when they began devising means for measuring its passing. The commonest method used by the ancients was based on observing the orbit of the sun by measuring the shadow cast by a gnomon against some form

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of dial marked off in hours. The Vedic lines quoted above suggest that from early times people have been aware, even though they may have had limited perceptions of space and time on earth, of the clock-like functioning of the universe. In the Mahābhārata we are told that 'Garga, the great Rishi' became astronomer-royal to Prthu. Kālajñāna or 'knowledge of time' is especially attributed to him and he is also associated with Kālayavana who is induced with Garga's powers (xii/340/95) and he is credited with a 'thorough knowledge of times and mastery of the science of stars' (xi/37/14). According to the *Visnu Purana* (ii/5), the ancient sage Garga, having propitiated Sesa acquired from him a knowledge of the principles of astronomy.

The sundial described in the early *Siddhantas* seems to be the practical outcome of the Vedic conception of time, the fundamental unit of which was the *sāvana* or civil day, reckoned generally from sunrise to sunrise and treated as a constant quantity. The *Pañcasiddhantika* of Varāhamihira (xiv/14–16) describes:

> Mark from the centre three times the end of the gnomon's shadow, and then describe two fish figures (common part of two intersecting circles). Thereupon describe a circle, taking for radius a string that is fastened to the point in which the two strings issuing from the heads of the fish figures intersect, and that is so long as to reach the three points marked. On the given day the shadow of the gnomon moves in that circle, and the base of the gnomon is the north-south line, and the interval in the north direction is the midday shadow. (iii/1–7)

This means that if we mark on any particular day the extremity of the shadow at three different times – these three points are supposed to be on a circle, the centre of which is found, in the usual way, by the so-called fish-figures. The *Surya Siddhānta* (iii/1–7) describes it in a more elaborate manner:

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> On a stony surface, made water level, or upon hard plaster, made level, there draw an even circle of a radius equal to any required number of digits of the gnomon. At its centre set up the gnomon of twelve digits of the measure fixed upon; and, where the extremity of its shadow touches the circle in the former and after parts of the day, there, fixing two points upon the circle, and calling them the forenoon and afternoon points, draw midway between them, by means of a fish figure, a north and south line. Midway between the north and south directions draw, by a fish figure, an east and west line: and in like manner, also by the fish figures, between the four cardinal directions, draw the intermediate directions. Draw a circumscribing square, by means of the lines going out from the centre; by the digits of its base lines projected upon that, is any given shadow reckoned. The east and west line is called the prime vertical (*samamandala*): it is likewise denominated the east and west hour circle (*unmandala*), and the equinoctial circle (*visuvan mandala*). Draw likewise an east and west line through the equinoctial shadow (*visuvadbhā*) ; the interval between any given shadow and the line of the equinoctial shadow denominated the measures of the amplitude (*agra*).

The other instrument of practical utility for time measurement described in ancient Indian works is the clepsydra, consisting of a metal bowl floating in a vessel of water. The clepsydra or water clock is referred to in the *Vedanga Jyotiṣa*, where the amount of water that measures a *nādikā* (= 24 minutes) is given. The more ancient form of water clock appears to have been simply a vessel with a small orifice at the bottom, through which the water flowed out in a *nādikā*, but later on there came into use the form described in the *Surya Siddhānta* (xiii/23): 'A copper vessel of pure water, sinks sixty times in a day and night, and is an accurate hemispherical instrument.' The *Pañcasiddhantika* description (xiv/32) is similar but in addition to the clepsydra it gives an alternative method: 'Or else a n ādikā

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may be measured by the time in which sixty "slokas" each containing sixty long syllables can be read out.'

Measurement of time intervals might have been more accurate nowadays with mechanical watches, quartz watches, or laser and atomic watches. However, this gives average standard time only. True or apparent time can be found only by inclination of the Sun from a vertical position. This is also subjective to measurement of longitude as simultaneous measuring of time through the Sun at two different places will be different, depending on the longitude. This is the reason as to why Chandrasekhar preferred the antique methods of gnomon and clepsydra (*S D*, 20/76–77, 7/72–75, etc.) although a mechanical clock was affordable. He was nevertheless convinced by Bhaskara's saying: 'But what does a man of genius want with instruments, about which numerous works have treated? Let him only take a staff in his hand, and look at any object along it, casting his eye from its end to the top. There is nothing of which he will not then tell; its altitude, dimensions, etc.' (*S S*, *Yantrā dhyaya*, 40). Rather, going a step ahead he contended: 'For the measurement of time, our own body also can be considered a gnomon and the distance of shadow, in this case, should be measured from the centre of one's feet.' (*S D*, 7/11–12)

In Indian astronomy, according to the *Siddhantas* the measurement of time on the microscale was being carried out by what is known as the anthropic principle which has been paraphrased by Stephen Hawking as: 'We see the universe the way it is because if it had been different we would not be here!' (*A Brief History of Time*, p.130–131) The basic unit of Indian scale is *prāna* (or *asu*) which is the time taken for inhalation or exhalation by any normal human being. It is also the time taken for pronouncing ten-long syllable (*guruvarna*). It is found to be about four seconds. Six *prānas* constitute a *vinādi*, sixty *vinādi* a *nadi* (*nādikā* or *ghatika*) and sixty *nādis* a day. There are also other units of

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time in which *nimesa* (the twinkling of an eye) is the basis. Chandrasekhar provides the table in accordance with the *Siddhānta Śiromani* (S S, 1/16–18) in which a *nimesa* consists of 3000 *trtis* (time taken by a sharp needle to pierce a soft lotus petal). This measure of *truti*, the smallest unit of time in Indian astronomy, is also found in the *Vateswarsiddhanta* (*Madhyama*, seventh sloka). A *truti* is found to be about 2,916,000,000[th] part of a day, according to the *Siddhānta Śiromani* and in terms of our modern unit of time approximately 0.0003 seconds.

It is significant that time has not only been considered at a microcosmic level but also at a macrocosmic level. Based on observations of periodic events such as the sunrise and sunset, new moon and full moon – rising and setting of stars, a working scale of time consisting of day, fortnight, month, and year has been used from early times. Āryabhatta (1) furnished a stanza (*Golapāda*-48) regarding his astronomical methods which says: 'The day-maker has been determined from the conjunction of the earth (or the horizon) and the sun; and the moon from her conjunctions with the sun. In the same way, the "star-planets" have been determined from their conjunctions with the moon.' It has been shown in a study of the stanza that by these methods the sidereal periods of the Sun, Mars, Jupiter, and Saturn, as well as the synodic month and hence the sidereal months, may be determined. Also the geocentric sidereal periods of Mercury and Venus may be found to be the same as the sidereal period of the Sun. (P C Sengupta, *Astronomy in Ancient India*, *The Cultural Heritage of India*, vol. vi, p.81)

The flights of imagination of the Indian astronomers in conceiving time can be seen from the introduction to the *Brhat Samhitā* where Varāhamihira has given a conspectus of the astronomical knowledge of his time and which serves as a typical outline of the contents of an Indian astronomical *siddhānta*. He writes:

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As to mathematical astronomy, he must know the divisions of heaven and of time, in ages, years, half-years, seasons, months, half months, days, watches, *muhurtas*, *ghatis* , *palas*, *prānas*, *vipalās*, *prativipalās* etc., as taught in these five *Siddhantas* – the *Paulisa*, *Romaka*, *Vāsistha*, *Saura* and *Brahmā Siddhānta*. He must know the reason why there are four kinds of months – solar, *sāvana*, sidereal, and lunar – and how it happens. There are added months and subtractive days. He must know the beginning and end of the Jovian cycle of sixty years, of the cycles, years, days, hours and their respective lords. He must be able to explain in what respect the reckoning after solar time shows similarity or difference compared with lunar, sidereal and *sāvana* reckoning of time and to what use each of these is adapted or not. And when there is a discrepancy between the *siddhantas* he must be able to prove experimentally, by means of the agreement between the shadow and the clepsydra, between observation and calculation, at what moment the sun has reached the solsticial point, and at how many *ghatikas* the sun enters the prime vertical. He must know the cause of the swift and slow motion, the northern and southern course, and the moving in an epicycle of the sun and the other planets. He must tell the moment of commencement and separation, the direction, measure, duration, amount of obscuration, colour and place of the eclipses of the sun and moon; also the future conjunctions and hostile encounters of the nine planets. He must be skilful in ascertaining the distance of each planet from the earth, expressed in *yojanas*; further the dimensions of their orbits, and the distance of the places on earth in *yojanas*. He ought to be clever in geometrical operations and in the calculation of time, in order to determine the form of the earth, the circle of the circuit of the asterisms, etc., the depression of the pole, the ascensional differences in time, the rising of the signs; the *ghatikas* corresponding to the shadow of the gnomon, and such like processes.

Cf. *Hindu Astronomy*, G R Kaye, pp.50–51

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Accordingly Chandrasekhar's range of time runs from *truti* to *pralay* (*Yatra trutyadi kalah pralaya caramakah khecaranam pracarah*, *S D*, 1/17) i.e., from alpha to omega, a scale that outmeasures a universe.

In his exclusive chapter on time (*Kālādhikarah*, *S D*, Ch. 22) Chandrasekhar states that *kala* (time) is of two types: *Nitya* (eternal) and *Janya* (transforming), (*S D* 22/2–3). This type of differentiation brings in the metaphysical problem of time and eternity. Metaphysically, time as continuum contrasts with the eternity which is not in time. But the Indian classical literature holds that the underlying reality is time as well as eternity. Quoting from the *Kurma Purana*, *Smrti*, *Yogavāsistha Rāmāyana*, Manusmrti, and above all the Veda, Chandrasekhar states that everything of the world is subject to the flow of time, but time itself is the moving image of eternity. God himself is the eternal time out of whom the empirical or *Janya* time has been created. He is within every point and yet beyond everything (*S D*, 22/4–13). Accordingly eternity is understood by Chandrasekhar in the sense of an unextended point of time which is *Now*. Both past and future are simultaneously present in this *Eternal Now*. The universe is an everlasting succession of events but its ground is the timeless *Now* of the Brahmā.

But, from Einstein onwards the scientists have denied the existence of an *eternal now*. As Eddington says:

> A year or so later Einstein made a slight amendment to his law to meet certain difficulties that he encountered in his theory. There was just one place where the theory did not seem to work properly, and that was infinity. I think Einstein showed his greatness in the simple and drastic way in which he disposed of difficulties at infinity. He abolished infinity.
>
> *The Expanding Universe*, p.21

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Similarly Roger Penrose states:

> According to relativity there is not really such a thing as the 'now' at all.
>
> *The Emperor's New Mind*, p.392

The existence of the *eternal now* is sometimes denied on the ground that a temporal order cannot co-exist with another order which is not temporal; and that it is impossible for a changing substance to be united with a changeless substance. 'This objection', Aldous Huxley argues, 'would be valid if the non-temporal order were of a mechanical nature, or if the changeless substance were possessed of spatial and material qualities. But according to the Perennial Philosophy, the *eternal now* is a consciousness; the divine Ground is spirit, the being of Brahmā is *chit* or knowledge. That a temporal world should be known and, in being known, sustained and perpetually created by an eternal consciousness is an idea which contains nothing self-contradictory.' (*Perennial Philosophy*, Fontana Books, p.194)

There are arguments directed against those who, like Chandrasekhar, have asserted that the eternal ground can be unitively known by human minds. This claim is regarded as absurd because it involves the assertion: 'at one time I am eternal, at another time I am in time' (*S D*, 22, 8–15). But this statement is absurd only if man is a being of twofold nature, capable of living on only one level. But if, as the exponents of the perennial philosophy have always maintained, man is not only a body and a psyche, but also a spirit, and if he can, at will, live either on the merely human plane or else in harmony and even in union with the divine ground of his being, the statement makes perfectly good sense.

It seems incompatible that Chandrasekhar, who boasts, like Newton, 'I make no hypotheses', has asserted the

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existence of *eternal now* despite the fact that it is not observed. The fact that absolute tim e cannot be observed is not by itself fatal to the view that it should be accepted. Because science asks us to believe in electrons, protons, and neutrons and so many others none of which can be directly observed. Chandrasekhar did not think that astronomy could dispense with inferences that go beyond observation.

Up to the beginning of the twentieth century people believed in an absolute time. Even Newton who was supposed to know all about time had expressed his ideas in *The Principia*:

> I do not define time, space, place and motion, as being well known to all. Only I must observe, that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects. And then arise certain prejudices, for the removal of which, it will be convenient to distinguish them into absolute and relative, true and apparent, mathematical and common. Absolute, true, and mathematical time, of itself, and from its own nature flows equally without regard to anything external, and by another name is called duration: relative, apparent, and common time, is some sensible external (whether accurate or unequable) measure of duration by the means of motion, which is commonly used instead of true time; such as an hour, a day, a month, a year.
>
> Cf. *Human Knowledge*, Bertrand Russell, 1997, Ch. V, p.284

Newton had gone on to explain:

> Absolute time, in astronomy, is distinguished from relative by the equation or correction of the vulgar time. For the natural days are truly unequal, though they are commonly considered as equal, and used for a measure of time; astronomers correct this inequality for their more accurate deducing of the celestial motions. It may be that there is no such thing as an equable motion, whereby time may be

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> accurately measured. All motions may be accelerated and retarded; but the true or equable progress of absolute time is liable to no change. The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all: and therefore it ought to be distinguished from what are only sensible measures thereof; and out of which we collect it, by means of the astronomical equation. The necessity of which equation, for determining the times of a phenomenon, is evinced as well from the experiments of the pendulum clock, as by eclipses of the satellites of Jupiter.
>
> Cf. *The Structure of the Universe*, G J Whitrow, Hutchinson's University Library, 1949, pp.47– 48

According to Bertrand Russell the process of arriving at *absolute* or *mathematical* time is essentially as follows:

> There are a number of periodic motions – the rotations and revolutions of the earth and the planets, the tides, the vibrations of a tuning fork, the heartbeats of a healthy man at rest – which are such that, if one of them is assumed to be uniform, all the others are approximately uniform. If we take one of them, say the earth's rotation, as uniform by definition, we can arrive at physical laws – notably the law of gravitation – which explain the phenomena, and show why the other periodic motions are approximately uniform. But unfortunately, the laws so established are only approximate, and, what is more, they show that the earth's rotation should suffer retardation by tidal friction. This is self-contradictory if the earth's rotation is taken as the measure of time; we therefore seek a different measure, which shall also make our physical laws approximate more nearly to exact truth. It is found convenient not to take any actual motion as 'defining' the measure of time, but to adopt a compromise measure which makes physical laws as accurate as possible. It is this compromise measure that serves the purposes for which Newton invoked 'absolute' time.
>
> *Human Knowledge*, p.285

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This compromise measure has always been adopted in all works of classical astronomy in the form of calculating mean position of planets through *ahargana* (sum of days). This refers to a method of calculating, by means of the number of years, intercalary months and omitted *tithis* in a *yuga* or *kalpa*, the number of civil or *sāvana* days that have elapsed from a certain period, when the years, months, and *tithis*, in which dates are generally expressed, are known. In order to make their calculation approximately more near to exact truth they have found out various aspects of the phenomena such as: *aksa valana* (deflection due to latitude), *ayanavalana* (deflection due to obliquity: *S D*, 7/4, 8/59, 69, 10/3, 21/193); *carasamskāra* (ascensional correction: *S D* 4/25, 6/104, 112); *desāntara* (difference in longitudes of a given place and the prime meridian: *S D* 4/9, 21, 41); *digamsasamskāra* (correction of co-azimuth: *S D* 6/3, 13); *ayanāmsa* and *ayanāmsasamskāra* (phenomenon of the precession of the equinoxes and its correction: *S D* 5/2, 12/40); *bhujāntara samskāra* (correction for equation of time *S D* 4/14, 5/3, 7/2); *udayāntarasamskāra* (correction of the celestial longitude on account of the equation of time due to obliquity of the ecliptic, complementary to the *bhujāntara*: *S D* 4/33, 37, 6/117); and an exhaustive number of other aspects.

However, this absolute time, embedded in the technique of classical astronomy, was generally rejected by the theory of relativity on the ground that there was no reason to suppose that the absolute time represented a physical reality. As has been very aptly expressed in verse:

> Our world was clothed in mystery black as night
> Till Isaac Newton said: 'Let there be light!'
> But Satan was not long to fret and frown,
> Soon Einstein came to put things upside down.

Incidentally, the first and the second couplets of this verse were written by different authors with an interval of about two

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hundred years! (Cf. *This Fascinating Astronomy*, V Komarov, tr. N Kittell, Mir Publishers, Moscow, 1985, p.40)

'Space–Time', from a philosophical and imaginative point of view, is perhaps the most important of all the novelties that Einstein introduced and most of the curious things in the theory of relativity are connected with the velocity of light. The theory which was discovered a year after Chandrasekhar's demise granted no absolute meaning to space, time, and motion, declared the ether superfluous, allowed no single privileged causal account for physical phenomena, implicated the observers in all observations and predicted a host of attendant effects such as length contraction and time dilation. Amid this flux of new ideas, the loss of absolute space, time, and the ether, there remained but one constant of unique significance, one *truth* that remained independent of all reference frames – the speed of light, which had never been taken into consideration by classical astronomers. The credibility of classical astronomy like that of Chandrasekhar ought to be reviewed in the event of the validity of the theory of relativity.

The discovery that the speed of light appeared the same to every observer, no matter how he was moving, led to the theory of relativity and in that one had to abandon the idea that there was a unique, absolute time. Instead each observer would have his own measure of time as recorded by a clock that he carried; clocks carried by different observers would not necessarily agree. Thus, time became a more personal concept relative to the observer who measured it. The way the problem due to relativity with respect to space–time, as has been viewed by Bertrand Russell, comes in is this:

> Suppose an astronomer observes an event in the sun, and notes the time of his observation; he will infer that the

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> event happened about eight minutes before his observation, since that is the length of time that it takes light to travel from the sun to the earth. But now suppose that the earth were travelling very fast towards the sun or away from it. Unless you already knew at what movement, by terrestrial time, the event on the sun took place, you would not known how far the light had to travel, and therefore your observation would not enable you to know when the event in the sun had taken place. That is to say, there would be no definite answer to the question: What events on earth were simultaneous with the solar event that you had observed? From the ambiguity of simultaneity it follows that there is a parallel ambiguity in the conception of distance. If two bodies are in relative motion, their distance apart is continually changing, and in pre-relativity physics there was supposed to be such a quantity as their 'distance at a given instant'. But if there is ambiguity as to what is the same instant for the two bodies, there is also ambiguity as to 'distance at a given instant'.
>
> *Human Knowledge*, pp.305–306

Moreover:

> The question now arises; what really is measured by a clock? When we speak of a clock in the theory of relativity, we do not mean only clocks made by human hands: we mean anything which goes through some regular periodic performance. The earth is a clock, because it rotates once in every twenty-three hours and fifty-six minutes. An atom is a clock, because it emits light waves of very definite frequencies: these are visible as bright lines in the spectrum of the atom. The world is full of periodic occurrences, and fundamental mechanisms, such as atoms, show as extraordinary similarity in different parts of the universe. Any one of these periodic occurrences may be used for measuring time, the only advantage of humanly manufactured clock is that they are especially easy to observe. However… the question remains if cosmic time is

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> abandoned, what is really measured by a clock in the wide sense that we have just given to the term?
>
> *ABC of Relativity*, pp.39–40, Unwin Paperbacks, London 1990

Reality, as we see relativistically, makes the measurement of distances relative, in just the same way as the measurement of time is found to be relative. There is no longer a universal time which can be applied without ambiguity to any part of the universe; there are only the various *proper* times of the various bodies in the universe, which agree approximately for two bodies which are not in rapid motion, but never agree exactly except for two bodies which are at rest relative to each other.

In spite of the anomaly, no doubt, astronomers like Chandrasekhar could be telling the exact hour and minute when an eclipse had to be total at any given spot in Orissa and it seems obvious that they could be speaking of the positions of planets at a given instant. How come it was being possible to predict, that too without taking relativity into account!

It was not that the classical astronomers were ignorant of space–time continuum and the conjoining hyphen represented by the interval between two events upon which objective measurement is possible. But they were certainly oblivious of the fact that the velocity of light could be a factor of conversion for measurement of this space–time interval. They believed that the size of the image of an object is inversely proportional to the distance from the eyes of the observer but by that their sight does not take more time to be located as long as the object remains within the limits of their vision.

Regarding the limits of visibility Chandrasekhar writes:

Satāmsastejasolabhya ititannirnaye sthite
Dvisahasragune dure sva vyāsāttigmadrisyateh
Usnasparsa samāptih syāt kiranānām nabhasthale

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Anyagrahānāmrksānām satadvaya gunepathi
Sitosnasparsanāsāh syātta thā bhoumasya tejasash
Sparsāntasthānatah svāmsu vyaptih pancasata gunaih
Adhika kirana vyāptemārge tattva gunādhike
Drstisimetyanumitam dipārkendvanubhutitah
Vyāsohi suryabimbasya khakhak hāksādri yojanah
Sparsakarnatadusrānām prayutaghnābdhivāsavah
Kirana vyāpti karno'sya Kotighnanakha bhudharah
Kha Khābhra dhrtayah Koti gunitādarusana sarti
Kāladhvanonrmānam yattadbhrāngāgni tāditam
Divyamānam bhavettena byāsosya satakotibhih
Yojanaih sammito'ndasya nr māne nāsukah punah
Khakhakhābhrā bhrakhābhrasad bahni bhirmatah!
Brahmāndāntah khakaksārka bhaganakirana dhvasta bisvaktamisrā
Laksaghna bhrāngabhubhr nna vakha gunasivai yojanaih sammitāsmāt
Seksākaksaiva bhānoravitanu vikalā dvādasam so pi drsyo
nyesām liptā dvisaptam saka itaramata vyanjakamvacmikincit.

S D, 19/111–119

(Spread of effulgence is proportional to area. Hence the effulgence from one-tenth of diameter will reach one -tenth of distance reached by effulgence from full diameter. At ten times of the distance, effulgence becomes one-hundredth. Hence at a distance of 200 times the sun's diameter, heat of the rays vanishes. The heat of the planets and other stars also vanishes at a distance of 200 times their diameter because their effulgence is one-hundredth of the sun. Similar is the heat of earth's energy. Brightness of the ray however, remains up to fifty times this distance. Visibility of the rays is further twenty-five times this distance. This limit has been estimated by me by comparing the light of the wick lamp (*dipa*) with that of the sun and the moon. Diameter of the sun is 72,000 *yojanas*. So the limit of its heat is up to 144,000,000 *yojanas*. Brightness of its rays is up to 7,200,000,000 *yojanas*, and the limit of its visibility is 180,000,000,000 *yojanas*. The human standard of distance

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and time multiplied by 360° give divine standard according to which the diameter of the visible part of the universe is 1,000,000,000 yojanas. Hence in human standard it is 360,000,000,000. The limit of visibility of the sun determines the visibility of stars and this is the visibility orbit of the sun. The circumference of this part of the visible universe is 1,130,976,000,000 yojanas. At this distance the angular diameter of the sun is one-twelfth *vikala* and that of the other planets is approximately one-seventy-second of this value.)

This passage suggests that the unaided human vision can go up to the specified limit within which heavenly bodies can be glanced and the lapse of time for a glance (nimesa) is too small to be accounted for. The question of accuracy of the figures given is not so important as the fact that the speed of sight has been thought to be independent of and greater than the velocity of light. Chandrasekhar's views on perception may be compared with those of Empedocles, Plato, and many others as stated by Arthur Zajonc:

> If during the act of sight something passes from the eye to the object seen, then in seeing the distant stars, something must pass through the greatest imaginable distance, and do so in an instant. After all, on opening our eyes, the entire world from horizon to horizon, and out to the most remote star or planet, immediately springs into view. Whatever travels there must do so at the highest speed. The measurement implicit in this argument, a common one in antiquity, was not actually a measurement of the speed of light, but really of the 'speed of sight'. The concern of ancient authors with the speed of perception continued for two thousand years. John Pecham, the most widely read medieval optician, wrote only of it, and not the speed of light, in his important work *Perspectiva Communis*.
>
> *Catching the Light*, Oxford, 1993, pp.262–263

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By careful observation of the moons of Jupiter and using Cassini's new measurement of the planetary distances from the sun, Rømer was able to show that light travels at a finite, if extraordinarily high, speed. Delay in occurrence of eclipse of Jupiter's moon might be caused as much by the positional change. How can an eclipse be seen unless and until it occurs? Why should an eclipse be expected to occur always after a fixed interval of time? On the other hand there are more obvious reasons to say that the speed of sight is greater than the speed of light. Light from the sun is being supposed to take eight minutes to reach our eyes. But our sight reaches the sun within a twinkling!

Therefore it may be stated, as has been said by Bertrand Russell, that 'the theory of relativity does not affect the space and time of perception'. (*Human Knowledge*, p.309)

A peculiar characteristic of time which has been claimed as post-relativistic discovery is that time should appear to run slower near a massive body like the earth. To someone high up, it would appear that everything down below was taking longer to happen. This prediction was tested in 1962, using a pair of very accurate clocks mounted at the top and bottom of a water tower. The clock at the bottom, which was nearer the earth, was found to run slower, in exact agreement with general relativity (Stephen Hawking, *A Brief History of Time*, p.35). The effect of this property of time has been described as the twins' paradox in Hawking's book. Suppose that one of a pair of twins goes to live on the top of a mountain while the other stays at sea level. The first of the twins would age faster than the second. In this case the difference in ages would be very small, but it would be much larger if one of the twins went for a long trip in a spaceship at nearly the speed of light. When he returned, he would be much younger than the one who stayed on earth. (Ibid., pp.35–36)

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A more detailed illustration has been supplied by Professor Reichenbach in Bertrand Russell's *Human Knowledge* (p.291). But the astonishing fact is that it was known to Indian astronomers since time immemorial in a mythological manner, if not in a physical manner. Otherwise, such a meticulous standard of time measurement could not have evolved, as has been pursued by Chandrasekhar in the following categorisation of human and divine scales:

> One lunar month equals to a day and night of the dead souls. 360 such days (360 lunar months) make a year of them and there would be 10,631 solar days in it... 360 divine (*daiva*) or demoniac (*asura*) days i.e. 360 solar years make a divine or demoniac year which consists of 131493/9 solar days.
>
> S D, 22/67–69

Thus, the Hindu belief in which Gods or heavenly beings remain ever young (*ajara*) was nevertheless a cultural innuendo that can still cope with relative time dilation, as if the Hindus had been able to realise time under velocity faster than light. Nevertheless, it can be suggested in principle that along with the world of velocities that are lower than that of light, there exists another world in which the velocity of light is not the upper but the lower limit of possible speeds (tachyon universe, from the Greek word *takhys*, which means fast), that this latter world exists undetected as it has no points of interaction with the former one. Of late, a number of works have been published whose authors consider the probability of 'supralight' particles which they have called tachyons.

Ambivalent to our feelings of fugitiveness is the sensation of the succession of time. We cannot help thinking that we have been led almost inevitably to the future from a past.

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Time seems to be moving ever forward as if it is an irreversible one-way process. Time had been compared to an ever flowing unceasing stream in which one can never take a bath twice, but nowadays the phrase 'arrow of time' is being used. Eddington has said: 'I shall use the phrase "time's arrow" to express this one-way property of time which has no analogue in space.' (*The Nature of Physical World*, p.69)

The explanation that is usually given as to why or where this irreversibility comes from is that it is forbidden by the second law of thermodynamics, which states that in any closed system disorder, or entropy, always increases with time. According to Stephen Hawking, there are at least three different arrows of time. First, there is the thermodynamic arrow of time, the direction of time in which disorder or entropy increases. Then, there is the psychological arrow of time, the direction in which we feel time passes, the direction in which we remember the past but not the future. Finally, there is the cosmological arrow of time, the direction in which the universe is expanding rather than contracting. He further argues that the no-boundary condition for the universe, together with the weak anthropic principle, can explain why all three arrows point in the same direction, and moreover, why a well-defined arrow of time should exist at all. (*A Brief History of Time*, pp.151–153)

The second law of thermodynamics or the concept of entropy increasing with time, might seem something new to the Western mind, but it was the foreboding conception of the ancient Hindu religion and astronomy. According to the Indian conception, *krta yuga*, the first of the cycle of ages, is the perfectly ordered or 'four-quartered' *yuga*. Dharma, the order of the world is during this period firm on its four legs, in the form of a sacred bull, with one hundred per cent strength and four quarters, effective as an

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all-pervading structural element in the organism of the universe. As the life process of the world organism gains momentum, however, order loses ground. Dharma vanishes quarter by quarter, while its converse gains the field. In *tretā yuga*, the sacred bull stands on three legs. *Dvāpara yuga* is the age of the dangerous balance between order and disorder and the bull of ethical order, instead of firmly standing on four legs, or resting safely on three, now balances on two. Finally, *kali yuga*, the dark age, miserably subsists on twenty-five per cent of the full strength of dharma or the emblematic bull stands only on one leg (*Vāyu Purana*, 97/65–66, Bhagavat III. 11, 21–41, *Matsya Purana*, p.484). Chandrasekhar has said: '*Kritadayo dhammapada kramena, catvaraete yuga sajnakasc.*' (*S D*, 1/34)

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Chapter VIII

SOLVITUR AMBULANDO

This Latin proverb suggests an anthropic principle that the problem of reality of motion is solved by walking. The current ideas about the motion of bodies date back to Galileo and Newton. Prior to them, people in the West believed Aristotle who said that the natural state of a body was to be at rest, and that it moved only if driven by a force or impulse. It is said that the ancient Greeks had a marvellous understanding of things static – rigid geometrical shapes, or bodies in equilibrium, but they had no good conception of the laws governing the way that bodies actually move, the beautiful way in which nature actually controls the change in location of bodies from one moment to the next. With the publication of Galileo's *Discorsi* in 1638 the new subject of dynamics was launched.

One consequence of the dynamical laws that Galileo and Newton developed was that uniform straight-line motion is physically completely indistinguishable from the state of rest (i.e. of absence of motion); there is no local way of telling uniform motion from rest. Galileo gave a very graphic description of it in terms of a metaphor:

> Shut yourself up with some friend in the main cabin below decks on some large ship, and have with you there some flies, butterflies, and other small flying animals. Have a large bowl of water with some fish in it; hang up a bottle that empties drop by drop into a wide vessel beneath it. With the ship standing still, observe carefully how the little animals fly with equal speed to all sides of the cabin. The

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> fish swim indifferently in all directions; the drops fall into the vessel beneath... When you have observed all these things carefully... have the ship proceed with any speed you like so long as the motion is uniform and not fluctuating this way and that. You will discover not the least change in all the effects named, nor could you tell from any of them whether the ship was moving or standing still... The droplets will fall as before into the vessel beneath without dropping toward the stern, although while the drops are in the air the ship runs many spans. The fish in their water will swim toward the front of their bowl with no more effort than toward the back, and will go with equal ease to bait placed anywhere around the edges of the bowl. Finally, the butterflies and flies will continue their flights indifferently towards every side, nor will it ever happen that they are concentrated towards the stern, as if tired out from keeping up with the course of the ship, from which they will have been separated during long intervals by keeping themselves in the air.
>
> Cf. *The Emperor's New Mind*, pp.211–212

This significant fact, known as the Principle of Galilean relativity is actually crucial in order that the Copernican point of view can make dynamical sense. Copernicus (1473–1543) and even Aristarchos (310–230 BC) had put forward the picture in which the sun remains at rest while the earth, as well as being in rotation about its own axis, moves in orbit around the sun. Copernicus argued:

> Why should we not admit, with regard to the daily rotation, that the appearance is in the heavens and the reality in the earth? The situation closely resembles what Virgil's Aeneid says: 'Forth from the harbour we sail, and the land and the cities slip back ward. For when a ship is floating calmly along, the sailors see its motion mirrored in everything outside, while on the other hand they suppose that they are stationary, together with everything on board.

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> In the same way the motion of the earth can unquestionably produce the impression that the entire universe is rotating.
>
> Cf. N Copernicus, *On the Revolutions*, J Dobrzycki (ed.), (tr.) E Rosen, Baltimore: John Hopkins Press, 1978, p.16

But the question as to why we are not aware of this motion which would amount to some 100,000 km/hr poses a genuine and deep puzzle for the Copernican point of view. If the earlier Aristotelian view of dynamics had been correct, in which the actual velocity of a system in its motion through space would affect its dynamical behaviour, the earth's motion would surely be something very directly evident to us. Of course, Galilean relativity makes it clear how the earth can be in motion, yet this motion is not something that can be directly perceived.

It was not unbecoming that in 1616 the Catholic Church placed Copernicus' work on its list of forbidden books 'until corrected' by local ecclesiastical censors, as the epochal confrontation between the two views of the world – Aristotelian or Ptolemaic and Copernican – reached a climax. Even some of Copernicus' admirers like Osiander argued that he had not really believed in a heliocentric universe but had merely proposed it as a convenience for calculating the motion of the planets. However, Galileo's *Dialogue Concerning the Two Chief Systems of the World* came out in 1962.

The book stated how three friends met on four successive days to discuss the two rival theories of the universe, ignoring that of Tycho Brahe. They ranged over all the arguments on both sides. One of the characters acted as the spokesman of Galileo himself. He put forward the fresh evidence based upon the telescopic discoveries. The book was written with great literary skill. On the first day the three friends debated whether heavy bodies fell in order

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to reach the fixed centre of the universe or (as Galileo supposed) in order to reach the centre of the moving earth. On the second day they discussed the earth's daily turning on its axis. The point was made that the earth could hardly remain at rest if everything outside were being carried round in a vast daily whirl, whereas, on the Copernican view, the earth was so small in comparison with the rest of the universe that it could easily rotate without affecting anything outside itself. On the third day they argued for and against the view that the earth revolved round the sun just as the little moons revolved around Jupiter; and for the last day Galileo provided an explanation of the tides which later proved to be mistaken. Galileo had been persecuted for this. There is a legend that, as he rose to his feet after his forced submission to the inquisition and his denial of the earth's motion, Galileo muttered: *eppur si muove* (i.e. it does move all the same!)

However, despite Galileo's emphatic muttering, a number of questions regarding the earth's movement had remained unanswered. For example, Du Bartas had collected many instances in his refutation of the Copernican system:

So, never should an Arrow Shot up right
In the same place upon the shooter light.
But would doo (rather) as at Sea, a stone
Aboord a ship upward uprightly throwne,
Which not within boord falles, but in the Flood
A- stern the ship, if so the wind be good.
So, should the Foules that take their nimble flight
From Westerne Marshes toward morning's light
and Zephirus, that in the Summer-time
Delights to visit Eurus in his clime,
And Bullets thund'red from the Canons throat
(Whose roaring drownes the Heavenly thunders note)
Should seeme recoyle: sithens the quicke careere
That our round Earth should daily gallop heere.

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Must needs exceed a hundred fold for swift,
Birds, Bullets, Winds; their winds, their force their drift.

Du Bartas, *His Divine Weeks and Works*, tr. 1605, Sylvester Gainesville, FL: Scholars' Fascimil es and Reprints, 1965, 4. 139–54, cf. *The Poetic Structure of the World*, Copernicus and Kepler, tr. Donald M Leslie, New York, Zone Books, 1990, pp.107–108

The matter, as it were, was never a 'let bygone be bygone' case. Norman Davidson has presented an extract from a text by the German philosopher Edmund Husserl (1859–1938). On the envelope containing the manuscript of the text was written: 'Overthrow of the Copernican system in the usual ideological interpretation. The Original ark does not move.' The extract states:

> The earth itself, in the original idea of its form, does not move, and is not at rest; only in reference to it do rest and movement first have a meaning. But, as earth has become a world body in the unlimited manifoldness of surrounding bodies, rest and movement lose their absoluteness. Movement and rest become necessarily relative. And if there could be a controversy about that, it could only be because the modern-day perception of the world as world of the infinite Corpernican horizon has not become, out of a really followed through worldview, a verified apperceived world.
>
> The apperceptive process has occurred in a way, but it has remained only as an indication for a verifying approach, instead of itself being construed as the ultimate proof.
>
> ...all proof has its subjective point of origin and ultimate anchorage in the ego, the proving ego. The proof of the new 'world idea', produced by a modification of interpretations has its first footing and essence in my field of perception and the oriental representation of that part of the world which has my body as the central body among others...
>
> A movement is necessarily relative when it is experienced in reference to a 'ground body' which is experienced as

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being at rest and with which my body is in union.

The relative ground body is itself relatively at rest and relatively in movement in relation to the surface of the earth which is not experienced, really originally experienced, as a body. As long as I do not have a conception of a new ground, one from which, in coherent movement, the earth can have meaning as a self-enclosed body in movement and rest, and as long as I do not achieve a conception of an interchange of grounds and through that a conception of both grounds becoming bodies, the earth is a ground but not a body. The earth does not move – I still say perhaps, it is at rest, but that can only say that each part of the earth that I or others separate off, or that separates itself off, that is at rest or moves, is a body. The earth is a totality, whose parts – when they are thought off on their own, as they can be, as being separated, separable – are bodies, but as a 'totality' it is not a body...

Cf. *Astronomy and the Imagination*, Norman Davidson Routledge and Kegan Paul, 1985, Appendix-I, pp.210–211

Vincent Descombes has commented on this:

It is certainly a striking illustration of the phenomenological step, which marks a return to the 'Lived World' as being at the origin of everything we know, and even the origin, die Ur-Arche. At first sight we tend to think that the question of the earth's motion must be decided by astronomy, i.e. by a science dealing with the planet as one celestial 'object' among others. Since astronomers have adopted the Copernican solution, we 'live' in the world in which we both see and say that 'the sun rises', and we think in another, where we know that the earth revolves around the sun. Conflict exists between the lived world (leben swelt) and the known world, between the 'percipio' and the 'cogito'.

Phenomenology invites us to resolve this conflict by ceasing to identify the real with the objective, and the lived through with the apparent. It sets out to show how the lived world lies at the origin of the known, or the objective world. And if

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> the lived world lies at the origin of the 'true world', it must, in its way, be more truthful than the true one.
>
> Science deals with the earth as an object and ascribes to it a movement in space. But this science was born 'on the earth', and it was here on this earth that it provided 'objective' definitions of motion, rest, space, and objectivity in general. Scientists' statements, for example, the Copernican statement, take their meaning from experiences acquired here. The 'here' which is the place of this first experience is not therefore a place in space, since it is the place of origin of the very notion of space.
>
> Qf. *Modern French Philosophy*, Ibid., pp.213–214

In Husserl's fragments on the immobility of the earth, Norman Davidson finds the seed of a new thought which struggles to realise a truth of human experience despite the overwhelming weight of current scientific teaching concerning the purely rational place of the earth in the cosmos. Husserl's musings appear to him, at first, obscur e and idiosyncratic. But if worked over, Davidson says, they hold together as an organic form in thought and can be grown into the flower which strives upwards in the dark, then eventually cracks open the brick. For want of a more pertinent example from modern philosophy, they are quoted here to serve their practical consequences a phenomenological astronomy and perhaps contribute to an understanding of Rudolf Steiner's remark that a time will come when the Ptolemaic system will again be correct. According to Davidson, two ways of observing phenomena emerge from this discussion. There is the dualistic approach which observes the phenomena and then takes a separated, removed position and imposes an explanation by means of other, unobserved factors (mathematics, for example) or indirectly observed factors (atomic physics, etc.). Then there is the integrated approach which observes the phenomena and enters them with the whole human being involved,

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identifying with them and waking up within them, so to speak. The total environment is not lost and the signature of the phenomena and their relation to life can be read. Arising from this latter approach in astronomy which starts from the geocentric view, other astronomies can develop, be they heliocentric or whatever. But they must be experienced and not just abstractly thought.

Taranirvisvadarsato jyotiskrdasisurya
Visvamābhāsi recanam.

R V, 1.50.4

Thou, Surya, out strippest all in speed; thou art visible to all; thou art the source of light; thou shinest throughout the entire firmament.

Sāyana, the famous commentator says that according to the *Smrti*, the sun moves 2,202 *yojanas* in half a twinkle of the eye. As scientists comprehend today, even with a velocity of 150 miles (250 km) per second, the sun takes 225 million years to orbit the galaxy (*The Illustrated Encyclopaedia of Astronomy and Space*, ed. Ian Ridpath, Thomas Y Crowell, New York, 1979, p.202). It is surprising to note that the Vedic theory of a moving sun has presently proved to be more tenable than the Copernican theory of a fixed sun.

On the other hand the Vedic people were not ignorant of the earth's movement. Like:

Stomāmsastvā vicārini pratistovant yakturbhih
Prayā vājam na hevantam perumasyasyarjuni.

R V, 5.84.2

Wanderer, in various ways thy worshippers hymn thee, Prthvi, with sacred songs; thee who, bright-hued tossest the swollen cloud like a neighing horse.

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A good number of hymns, suggestive of earth's movement, are there in the Vedic literature. But paradoxically almost all Indian treatises of astronomy, barring the *Aryabhattiyam*, have been based on the hypothesis that the earth is at the centre of the universe, that the sun, moon, planets and stars go around the earth. This is the most natural idea in the world. This earth seems steady, immobile, while we can see the heavenly bodies rising and setting each day. Every culture has leaped to the geocentric hypothesis.

Chandrasekhar has said: 'This is my conclusion that without any other base the earth is in the centre of space, surrounded by the orbits of the sun, planets and stars. The earth and all other planets are spherical. I will prove this view by replying to questions of persons having different opinion' (*S D*, 17/5). The paradox deepens when we see the following hymn of the Rig Veda: 'This altar is the uttermost end of the earth; this sacrifice (*yajna*) is the navel of the universe' (1/164/35). Some critics believe that the geocentric hypothesis is merely an assumption convenient for calculations done by the ancient astronomers (*S D*, vol. II, A K Upadhyaya, p.771). Had it been the case, astronomers would not have tried so hard to prove the immobility of the earth. It is said that the earth orbits the sun at a velocity of about 29.8 km/s (*This Fascinating Astronomy*, V Komarov, p.109). Compared to the velocity of the sun at which it orbits the galaxy, earth's velocity is too small to enable it to orbit the sun. The relative velocity of the earth ought to be faster than that of the sun; the relative velocity of the moon would be more than that of the earth in this case. And no star excepting the sun can possibly be seen from the surface of a so fast-moving earth.

There were philosophers far back in hoary antiquity who supposed that opposing principles or forces which cause self-movement, internal motion, and the replacement of one state by another, operate in the world. Each object, they

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said, is made up of opposite sides, which cannot exist without one another, since they presuppose one another, i.e. being diametrically opposed; such as life and death, light and darkness, movement and state of rest, etc. Then where do we find the state of rest if not in this world? It might be noted that, with Galilean relativity, there is no local physical meaning to be attached to the concept of being 'at rest'. It tells us that there is no absolute meaning to the 'state of rest'. If this is the case with the whole universe, how can motion be comprehended? However, in *The Principia*, Newton has expressed his ideas thus:

> Absolute motion is the translation of a body from one place into another; and relative motion the translation from one relative place into another. Thus in a ship under sail, the relative place of a body is that part of the ship which the body possesses; or that part of its cavity which the body fills, and which therefore moves together with the ship; and relative rest is the continuance of the body in the same part of the ship, or its cavity. But real, absolute rest is the continuance of the body in the same part of that immovable space in which the ship itself, its cavity and all that it contains, is moved. Wherefore, if the earth is really at rest, the body, which relatively rests in the ship, will really and absolutely move with the same velocity which the ship has on the earth. But if the earth also moves, the true and absolute motion of the body will arise, partly from the true motion of the earth in immovable space; partly from the relative motion of the ship on the earth; and if the body moves also relatively in the ship, its true motion will arise, partly from the true motion of the earth in immovable space, and partly from the relative motions as well of the ship on the earth as of the body on the ship; and from these relative motions will arise the relative motion of the body on the earth...
>
> Cf. *The Structure of the Universe*, G J Whitrow, p.47

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Accordingly, if the galaxy is supposed to be the sea and the solar system is supposed to be the ship, the earth would seem to be relatively at rest. In this sense the fixed -earth hypotheses holds good and Chandrasekhar's adherence to this should not be treated as a redoubt in a fool's paradise. Some of the reasonings which Chandrasekhar has held to prove the immobility of the earth are fairly convincing. For example, refuting the Copernican argument 'Forth from the harbour we sail, and the land and the cities slip backward', Chandrasekhar has said: 'If the earth is always moving from west to east, the wind ought to blow always from east to west. But does a silk flag hoisted on a pole always wag westward?' (*S D*, 17/42) If the earth is having rotational as well as orbital movement, how does the wind often stand still? If the diurnal motion of the earth can affect the movement of Foucault's swinging pendulum which is taken to prove convincingly the earth's diurnal motion, how does the wind stand at times so still that even a single piece of hair remains unruffled?

Quoting the *Siddhānta Śiromani*, Chandrasekhar therefore argues:

> As heat is a natural quality of the sun and the fire; coldness is of the moon; liquidity is of the water; hardness is of the rock and mobility is of the wind, similarly immobility is a natural quality of the earth.
>
> S D, 17/77

Like Zeno, the Greek philosopher of the fifth century BC who is best known for his paradoxes which appear to show that motion is impossible, Chandrasekhar has devised a number of paradoxes with the object of confuting the followers of the heliocentric hypothesis, such as: (1) rising of the same star in celestial sphere always at the same place, (2) increase or decrease of *mandaphala* and *sighraphala*

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(equation of centre due to the eccentricity of the orbit and equation of conjunction) of Mercury and Mars due to their *mandakendra* (angular distance of a heavenly body from its *mandocca*; anomaly from apogee or aphelion), (3) spots of the moon always look alike from the earth (4) paradoxical behaviour of light and heavy bodies, (5) movement of bodies under attraction in the direction of attraction, (6) non-existence of *sara* (deviation from ecliptic) of the sun, etc. (*S D*, Ch. 17). By means of the paradoxes arising out of these, Chandrasekhar has tried to disprove all the three types of motions (diurnal, annual, and declinal or *kranti*) of the earth. Of course, some of the arguments have been turned down by critics as misconceptions but many of them have still remained unanswered. The doubt raised by Chandrasekhar against the movement of the earth has not yet been successfully resolved.

The great advances in optics made during the last century suggested that it might be possible to measure the absolute velocity of the earth by an optical experiment. This was first attempted in 1887 by Michelson and Morley. According to the theory prevailing at that time, light moved at constant speed in an invisible substance called the ether. The earth's motion through the ether would produce a kind of wind so that the speed of light measured perpendicular to the earth's direction of motion would be different from that measured in line with the earth's direction of motion. Michelson and Morley compared the travel time of two light beams sent along optical paths at right angles to each other. Because of the predicted ether wind it was expected that the beam directed along the earth's line of motion would return later than the perpendicular beam. In fact, no detectable difference was found, a result of stunning unexpectedness which virtually invalidated the ether theory. The experiment has been repeated many times with increasing precision, but no difference in travel time has

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ever been detected. Michelson himself suggested that the earth dragged along the ether in its neighbourhood so that the velocity of the earth with respect to the ether would appear to be zero. This unexpected result might have been due to the earth happening to be at rest relative to the ether at that epoch, but Einstein suggested that the simplest explanation of this experiment was the hypothesis that the velocity of light is the same for all observers in uniform relative motion. Is it not the same for all observers in a relative state of rest?

Newton's first law states: 'Everybody remains in a state of rest or of uniform motion in a straight line, unless it is compelled by impressed forces to change that state.' Translating it into common physical language we can say that if no external force is impressed on a body, its acceleration is zero. But what about the state of rest? Is rest a special case of motion, when speed equals zero? What does and what does not the first law speak of? It only speaks of the case when the forces are zero and nothing else. Then what if the forces are not zero? The first law knows nothing about it. We can hardly point out even one case of motion *by inertia* in a pure form in nature, which would be in strict conformity with Newton's first law. For, any object, no matter where placed, is always subject to the gravitational influence of a host of celestial bodies, and without ignoring this influence Newton's first law can practically never be proved in nature.

Zeno, who may be regarded as the founder of the philosophy of infinity, appears in Plato's *Parmenides* as an instructor to Socrates. He invented four arguments to prove that motion is impossible, that Achilles can never overtake the tortoise, and that an arrow in flight is really at rest. After being refuted by Aristotle, and by every subsequent philosopher from that day to our own, these arguments were reinstated, and made the basis of a mathematical renaissance,

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by a German professor, who probably never dreamed of any connection between himself and Zeno. Weierstrass, Professor of Mathematics in the University of Berlin, by strictly banishing from mathematics the use of infinitesimals, has at last shown that we live in an unchanging world, and that the arrow in its flight is truly at rest. (*Mysticism and Logic*, B Russell. Unwin Books, 1963, Ch. V)

The Copernican theory has developed through the years like a living phenomenon. The early followers of Copernicus, while supporting to establish the sun -centred universe, each altered the original Copernican scheme in one way or another. Thus the solar system which they handed down to modern astronomy bore only a chequered resemblance to the original system of the revolution. Copernicus had put the sun in the privileged central position and mad e the planets including the earth revolve round the sun in combinations of excentrics and epicycles. But within a generation of the death of Copernicus, men had begun to ask whether space might not stretch indefinitely in all directions without any centre at all. The next generation saw the end of the eccentrics and epicycles, and of the perfectly circular motion of the heavenly bodies. An entirely new set of laws of motion had been proposed, equally applicable to earthly and heavenly bodies. The distinction between the earthly and the heavenly was fast disappearing. Our solar system had at first been supposed to be the unique. But soon the stars were conceived to be suns, each perhaps with its family and moving freely in space, with our sun itself such a moving star.

Resultantly, the old fixed landmarks to which earlier astronomers had been accustomed to refer the courses of the heavenly bodies, were cast away. And the old dispute over the rest or motion of the earth or sun could no longer be expressed in such simple terms. Several attempts had

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been made to prove that the earth is moving, and to measure its speed in relation to space itself, by means of ingenious optical experiments. The scientist on the earth is in much the same position as a passenger in a railway carriage who wants to find whether, and how fast, his train is moving. On the railway little signposts are there with the aid of which it is easy to find the speed of the train. But if the passenger cannot see anything out of the carriage window, he will not be able to say how fast the train is moving. Or if what he sees when he looks out is only another moving train on the adjoining track, he will be aware only of the difference of the speeds of the two trains – the motion of one train relative to the other. In this way, all attempts to measure the earth's speed relative to space itself have all failed. Angus Armitage of the University College, London, writes:

> It seems to be one of the laws of nature that t hey always must fail; that the scientist is looking for something that does not exist. It seems there are no fixed landmarks in space, only heavenly bodies floating about, like the moving train on the adjoining track. Hence we cannot say how fast, or in what direction, the Earth is moving through space, not because we are not clever enough to find out, but because the statement would have no meaning. All that we can say is that the Earth and the other heavenly bodies are moving relatively to one another like the two trains. If we are to say that any one of them is 'fixed', it is merely a matter of choice and convenience on our part in solving some particular problems. So we come back at the end to what we said at the beginning... that Copernicus made a choice and not a discovery when he decided to think of the planets as revolving about a central sun.
>
> *The World of Copernicus*, A Mentor Book, 1952, pp.159 –60

So also Chandrasekhar made a choice:

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> *Srastā srstvābhacakram dhruvayugalayutam sagraham samniyuktam*
> *Nityabhrāntā vanantodbhuvibhavikavikarmādyabhidvyaktihetoh*
> *Bhrāntebhānāmganetat prabhrti calatare pascimāsābhimukhyam*
> *Prācim nicocca vrttairbrajati khagatatih svalpagatyaiva tasmāt.*
>
> S D, 1/22

> After creation, the Creator set the celestial sphere to motion from east to west once in a day around the axis of the two celestial poles. With a slower motion the planets moved west to east relative to stars in epicycles (*nicoccavrtta*).

Current ideas about the motion of bodies date back to Galileo and Newton. Before them belief was in Aristotle who said that the natural state of a body was to be at rest and that it moved only when driven by a force. In particular, he thought that the earth was at rest. But it follows from Newton's laws that there is no unique standard of rest. If one sets aside for a moment the rotation of earth and its orbit round the sun, one could say that the earth was at rest and that a train on it was travelling north at ninety miles per hour or that the train was at rest and the earth was moving south at ninety miles per hour. If one carried out experiments with moving bodies on the train, all Newton's laws would still hold. For example, 'Playing ping -pong on the train, one would find that the ball obeyed Newton's laws just like a ball on a table by the track. So there is no way to tell whether it is the train or the earth that is moving.' (*A Brief History of Time*, p.18)

Believing to have observed absolute motion and as absolute motion implies absolute space and time, Newton had contended:

> The effects which distinguish absolute from relative motion are centrifugal forces, or those forces in circular motion which produce a tendency of recession from the axis. For in a circular motion which is purely relative no such forces exist, but in a true and absolute circular motion

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> they do exist, and are greater or less according to the quantity of the absolute motion.
>
> Cf. *The Structure of the Universe*, Whitrow, p.49

In order to substantiate it he had devised the following experiment:

> If a bucket, suspended by a long cord is so often turned about that finally the cord is strongly twisted, then is filled with water, and held at rest together with the water; and afterwards, by the action of a second force, it is suddenly set whirling about the contrary way, and continues, while the cord is untwisting itself, for sometime in this motion; the surface of the water will at first be level, just as it was before the vessel began to move; but subsequently, the vessel, by gradually communicating its motion to the water, will make it begin sensibly to rotate, and the water will recede little by little from the middle and rise up at the sides of the vessel; its surface assuming a concave form (as I have experienced) and the swifter the motion becomes, the higher will the water rise, till at last, performing its revolutions in the same times as the vessel, it becomes relatively at rest to it... At first when the relative motion of the water was greatest, that motion produced no tendency whatever of recess ion from the axis, the water made no endeavour to move towards the circumference, by rising at the sides of the vessel, but remained level, and for that reason its true circular motion had not yet begun. But afterwards, when the relative motion of the water had decreased, the rising of the water at the sides of the vessel indicated an endeavour to recede from the axis; and this endeavour revealed the real motion of the water, continually increasing, until it had reached its greatest point, when relatively the water was at rest in the vessel...
>
> Ibid., p.49

In this experiment it is implicitly assumed that it would yield the same result if it were performed in empty space. In

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the experiment carried out by Newton, the pail was at first rotating and then at rest relative to the earth. This criticism was made by Berkeley in his essay 'De Motu'. He showed that the motion of the pail only appears to be circular, but that in fact is very far from being circular because it is necessary to take into account the rotation of the earth about its axis, the revolution of the earth about the sun and so on. Berkeley concluded that it is not necessary to introduce the idea of absolute rotation and that all such motions can ultimately be related to the system of stars as frame of reference. He further argued:

> If every place is relative, then every motion is relative, and as motion cannot be understood without a determination of its direction which in its turn cannot be understood except in its relation to our or some other body... therefore, if we suppose that everything is annihilated except one globe, it would be impossible to imagine any movement of that globe. Let us imagine two globes and that besides them nothing else material exists, then the motion in a circle of these two globes round their common centre cannot be imagined. But suppose that the heaven of fixed stars was suddenly created and we shall be in a position to imagine the motion of the globes by their relative position to the different parts of the heaven.
>
> Ibid., p.50

Since Newton's time, other arguments of the same sort have accumulated. Foucault's pendulum, the flattening of the earth at the poles and the fact that bodies weigh less in low latitudes than in high ones, would enable us to infer that the earth rotates even if the sky were always covered with clouds; in fact, on Newtonian principles we can say that the rotation of the earth, not the revolution of the heavens, causes the succession of night and day and the rising and setting of the stars. But if space is purely relative,

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the difference between the statements 'the earth rotates' and 'the heavens revolve' is purely verbal; both are the ways of describing the same phenomena.

In quest of finding out the origin of motion of the heavenly bodies, when we come to Newton, and read the scholium appended to his definitions, we find him using as a matter of course a whole vocabulary which, taken literally, ascribes to *causes* in nature, a kind of power which properly belongs to one human being inducing another to act as he wishes him to act. *Causes* are said, in the twelfth paragraph of that scholium, to be '...forces impressed upon bodies for the generation of motion. True motion is neither generated nor altered, but by some force impressed upon the body moved.' The cause, for Newton, is not that which impresses the force, it is the force itself. It may be reminded that in Newton there is no law of universal causation. He not only does not assert that every event must have a cause but also explicitly denies it in two ways. First, in the case of a body moving freely, (even though its motion be what he calls *true* motion as distinct from relative motion) there is uncaused motion; for caused means constrained and free means unconstrained. Secondly, he asserts that there is such a thing as 'relative motion' but, as he puts it, 'relative motion may be generated or altered without any force impressed upon the body'. If, therefore, it were possible to show either that all motions are 'free' that is to say take place according to the laws having the same logical character as the Newtonian laws of motion; or that all motions are 'relative', then on Newton's own principles it would follow, as R G Collingwood has argued, that no motion is caused, and the cat would be out of the bag.

According to Collingwood:

> Taken *aupied de la lettre*, Newton is implying that a billiard ball struck by another and set in motion would have liked

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> to be left in peace; it is reluctant to move, and this reluctance, which is called inertia, has to be overcome by an effect on the part of the ball that strikes it. This effort costs the striker something, namely part of its own momentum, which it pays over to the sluggard ball as an inducement to move. I am not suggesting that this reduction of physics to social psychology is the doctrine Newton set out to teach; all I say is that he expounded it, no doubt as a metaphor beneath which the truths of physics are concealed. ...It would have become plain that there is no truth concealed beneath the animistic metaphor; and that 'the idea of causation' is simply a relic of animism foisted upon a science to which it is irrelevant.
>
> This is what modern physics has done. Developing the Newtonian doctrine in the simplest and most logical way, it has eliminated the notion of cause altogether.
>
> *An Essay on Metaphysics*, R G Collingwood, Oxford, Ch. XXIX, 1940, pp.326–27

In Newtonian mechanics, all physical events are reduced to the motion of material points in space caused by their mutual attraction, i.e. by the force of gravity. In order to put the effect of this force on a mass point into a precise mathematical form, Newton had to invent completely new concepts and mathematical techniques, those of differential calculus. When mathematics was used to describe the patterns that nature wove in space and time, the results were often spectacularly successful; none more so than in the description of the celestial motions. Newton's laws were held up as the paragon of scientific determinism. If anyone knew the present, those would enable him to reconstruct the past and predict the future. The French mathematician Pierre Simon Laplace showed, in his stupendous work in five volumes called *Mecanique Celeste*, that the laws of nature which Newton had discovered created a situation in which the future might be completely known by 'an intellect

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which at a given instant knew all the forces acting in nature, and the position of all things of which the world consists – supposing the said intellect were vast enough to subject these data to analysis – would embrace in the same formula the motions of the greatest bodies in the universe and those of the slightest atoms; nothing would be uncertain for it, and the future, like the past, would be present to its eyes' (quoted in M Capek, op. cit., p.122). When Laplace presented the first edition of his work to Napoleon – so the story goes – Napoleon remarked, 'Monsieur Laplace, they tell me you have written this large book on the system of the universe, and have never even mentioned its Creator.' To this Laplace, replied bluntly, 'I had no need for that hypothesis.' (*The Tao of Physics*, p.65)

Notwithstanding the deterministic argument that Laplace had given us, we are inclined to know a reason to account for the initial motion and this ultimate reason must be of such a kind as itself not to require a further reason to account for it. Because the notion of a first cause is the only alternative to the notion of an infinite regress and in this case God alone would possess that compulsive force which is expressed by the word *vis gravitatis* in Newtonian law of motion. Even Newton himself had nothing contrary to say; he supposed (exactly as has been supposed by Samanta Chandrasekhar) that at the creation the planets had been hurled by the hand of God in a tangential way, and had then been left by Him to the operation of the law of gravitation.

Of course, the conception of force which was prominent in the work of Galileo and Newton, turned out to be superfluous, and was eliminated from classical dynamics during the nineteenth century. The century had lasted just long enough for science to discover that certain phenomena, radiation and gravitation in particular, defied all attempts at a purely mechanical explanation. Then Einstein's law did not lend itself to any such interpretation in terms of forces,

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or indeed to any mechanical interpretation whatever. It was found to admit of an easy interpretation in terms of geometry. The effect of a mass gravitating matter was not, as Newton had imagined, to exude a *force*, but to distort the four-dimensional continuum in its neighbourhood. The moving planet was no longer drawn off from its rectilinear motion by the pull of a force, but by a curvature of the continuum. In 1905, Einstein propounded the supposed new law of nature in the form: 'Nature is such that it is impossible to determine absolute motion by any experiment whatever.' It was just a reversion of Newton's doctrine:

> It is possible that in the remote regions of the fixed stars or perhaps far beyond them, there may be some body absolutely at rest, but impossible to know, from the positions of bodies to one another in our regions, whether any of these do not keep the same position to that remote body. It follows that absolute rest cannot be determined from the position of bodies in our regions.
>
> *The Principia*, cf. *The Mysterious Universe*, Sir J Jeans, Cambridge, 1947, p.78

Astronomy has so far failed to discover Newton's 'body absolutely at rest' in the remote regions of the fixed stars, or perhaps far beyond them' but Chandrasekhar has aptly taken this earth itself to be that body absolutely at rest, as Einstein's principle now tells us that, so far as all the observable phenomena of nature are concerned we are free to define 'absolute rest' in any way we please. In the words of Sir James Jeans:

> It is a sensational message. We have a perfect right to say, if we so choose, that this room is at rest, and nature will not say us nay. If the earth has a speed of 1,000 miles a second through the ether, then we must suppose that the ether is blowing through this room 'like the wind through a grove

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of trees,' at 1,000 miles a second. And the principle of relativity assures us that all the phenomena of nature in this room are absolutely unaffected by this 1,000 miles-a-second wind, and would indeed be just the same if the wind blew at 100,000 miles a second – or indeed if there were no wind at all.

The Mysterious Universe, p.80

In a similar vein Chandrasekhar has said:

Tadāhariharinmukha prajabinā binācet kare
Vibharttvupari yastikām sikharajusta cinānsukām
Puraprabahadā sugrapracalitam tadālokyate
Sadāvarunadingmukham kimabanau parāsāmarut.

S D, 17/42

If the wind blows from the east and a person hoists a silk flag, does the flag always furl towards the west? Does the motion of the wind happen to be blowing from the east due to eastward rotation of the earth on its axis?

James Jeans has concluded:

Thus, although we are still far from any positive knowledge, it seems possible that there may be some factor, for which we have so far found no better name than 'fate', operating in nature to neutralise the cast- iron inevitability of the old law of causation. The future may not be as unalterably determined by the past as we used to think; in part at least it may rest on the knees of whatever gods there be.

Ibid., p.22

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Chapter IX

THE HERO OF THE HEAVEN

Bhubhrāntaibhacakra pascimagame siddhe kimāyāsato
Bhabhrāntai pravahākshyamaruta krti Visnoridamvaksacet
Isahsarsapa parvataust hiracalau kartrm samarthām nijām
Saktimvyaktu mimām ksamamacalayatyatrāstikimdusanam...

Yāstedharesa bahirangatatasthasakti
Yugmādvarānikhilasadgunajiva sadam
Sacchaktirantaratamh paramesvarasya
Sāmsairgahaih paribhuttāstikimatracitram...

Brahmānda kāranābdhau calatujalābalād vāmahābātavegāt
Kimvāsvāmambarasthain taduparіparitastātpurānādi siddham
Saptabdhidvipa bhubhrt prabhrtisubitatam nāstitat rāsmadukti
Vyaktibhutai tadandodaragata dharani nādyamudisyadrsyam.

S D, 17/147, 150, 159

If the westerly motion of the celestial sphere is merely the reflection of easterly motion of the earth, why did God want to create '*pravaha*' i.e. the celestial sailing wind with so much labour? Rather it is more reasonable to think that according to His desire a globule of mustard may be at a state of rest whereas a mountain cannot. To show that He is omnipotent, He has made this earth immovable... The earth having been created out of two divine forces of God, namely attachment (external) and detachment (internal), possesses both of them. As it is the only abode of life, the earth must posses His internal force of detachment upon which no external force can be impressed so as to cause motion. He is the unmoved mover, all in accordance with perhaps Heisenberg's 'uncertainty principle' which makes it impossible ever to say: 'An electron is here, at this precise

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spot, and is moving at just so many miles an hour.' ...In the ocean of causality of the universe this earth remains unmoved, never being blown away by sweeping celestial wave and remains as such in the vastness of space.

The ultimate cause has often been used as the basis for an argument for the existence of God in order to get the motion started originally. For if any being is to be conceived as necessarily existing and so not needing a cause outside itself, it is most plausible to conceive God as occupying this position.

Indian theology begins with the Vedas. At first it was pluralistic in character. But soon it developed into henotheism and then in due course into monotheism and monism. The main current of Upanishadic thought flows towards a monistic conception: there is one without a second (*Mundakopanisad*, 11.2.11/ *Chandogyopanisad*, VI. 2.1). The conception of God as the Creator of the universe thus dates back to the Vedic age, but nevertheless controversial it has always been (i.e. *kasmai devaya havisa vidhema*: Who is that god whom we shall offer our oblation, R V X.121). Buddhism in its original form does not concern itself with the question of God. In later Buddhism, however, arguments are adduced for proving the non-existence of God as Creator and architect of the universe (*Bodhicaryāvatara*, IX.119 f.) Jainism is atheistic in character in so far as it denies the existence of a supreme deity, the creator and the ruler of the universe. As Jinasena (c. 900) in his *Mahāpurana* states:

Some foolish men declare that a Creator made the world. The doctrine that the world was created is ill-advised, and should be rejected. If God created the world, where was He before creation? ...How could God have made the world without any raw material? If you say he made this first, and then the world, you are faced with an endless

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> regression... Know that the world is uncreated, as time itself is, without beginning and end.
>
> Cf. *Cosmos*, p.200

Of late, Stephen Hawking, considered nowadays to be the greatest living theoretical physicist and cosmologist who is using the incredibly 'complex string theory', has aptly provided the answer:

> The idea that space and time may form a closed surface without boundary also has profound implications for the role of God in the affairs of the universe. With the success of scientific theories in describing events, most people have come to believe that God allows the universe to evolve according to a set of laws and does not intervene in the universe to break these laws. However, the laws do not tell us what the universe should have looked like when it started – it would still be up to God to wind up the clockwork and choose how to start it off. So long as the universe had a beginning, we could suppose it had a creator. But if the universe is really completely self-contained, having no boundary or edge, it would have neither beginning nor end: it would simply be: What place, then, for a creator.
>
> *A Brief History of Time*, p.149

Thus, it seems as if God always has to be in constant conflict with science. Dr Raja Ramanna, the eminent nuclear physicist of India, feels: 'Had we not discarded the pragmatic spirit of Buddhism the way we did, the scientific activities of India would not have suffered a decline like they did,' and Joseph Needham feels: 'Neither in Islam, nor in India, nor the Far East was the substance and the stuff of Nature so depleted of sacramental and spiritual character, nor was the intellectual dimension of these conditions so enfeebled, as to enable a purely secular science of nature... to develop outside the matrix of traditional intellectual

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orthodoxy.' On the other hand science can now be interpreted more as trying to find God and his motives and ideas than trying to disprove his existence. (Dr Raja Ramanna's Introduction to *The Cultural Heritage of India*, vol. VI, Needham's comment in *Situating the History of Science*, p.203). As Stephen Hawking says:

> If we do discover a complete theory, it should in time be understandable in broad principle by everyone, not just a few scientists. Then we shall all, philosophers, scientist, and just ordinary people, be able to take part in the discussion of the question of why it is that we and the universe exist. If we find the answer to that, it would be the ultimate triumph of human reason – for then we would know the mind of God.
>
> Stephen Hawking, *A Brief History of Time*, p.185

It must not be forgotten that the role of God in traditional astronomy of India can be properly equated with the search for 'a theory of everything' of the present-day scientist. Though, like the modern physicists, they have failed to find out a precise formula for everything, they were least sceptical about the existence of God and His role in the affairs of the universe. But this aspect of the Indian treatise on astronomy has regrettably been largely entreated with neglect. Present-day professional astronomers hardly take care of the fact that the *Siddhantas* have ever been written perfectly in the idiom of an epic in which the a priori role of a hero is inevitable and none but God has the divine qualities of the protagonist.

Chandrasekhar defines his protagonist (*S D*, 18/1) in the light of the *Yogavāsistha*, which states:

> Many names have been given to the Absolute by the learned for practical purposes such as law, self, truth. It is called Person by the *Sāṅkhya* thinkers, Brahmā by

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> Vedantins, pure and simple consciousness by the *Vijñānavadins*, *sunya* by the Nihilists, the illuminator by the worshippers of the sun. It is also called the speaker, the thinker, the enjoyer of actions and the doer of them Siva for the worshippers of Siva and time for those who believe in Time alone.
>
> *Yogavāsistha*, 3, 1, 12/ 3, 5, 6–7/5.8.19

But above all he seems to believe in the principle that the more closely a science of nature approximates to the condition of consisting in its entirety of applied ma thematics, the more closely it approximates to the ideal of what a natural science ought to be, as if the book of Nature is written by the hand of God in the language of mathematics. Fully alive to the beauty of great contemplations to which his life is devoted desiring that others may share in his joys, he persuades mankind to impart to the successive generations the mechanical knowledge without which it is impossible to cross the threshold. Dry pedants possess themselves of the privilege of instilling this knowledge, they forget that it is to serve but as a key to open the doors of the temple; though they spend their lives on the steps leading up to those sacred doors, they turn their backs upon the temple so resolutely that its very existence is forgotten, and the eager youth, who would press forward to be initiated to its domes and arches, is bidden to turn back and count the steps (See *Mysticism and Logic and Other Essays*, *The Study of Mathematics*, Bertrand Russell, Unwin Books, 1963, p.48.) He knows 'One seated in the sleep of Super-conscience, a massed intelligence, blissful and the enjoyer of Bliss... This is the omnipotent, this is the omniscient, this is the inner control, this is the source of all' (*Māndukyopanisad*, Verses 5.6). A principle of active knowledge and free will superior to Mind and Creatrix of the world is then the intermediary power and state of being between that self-possession of the One and

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this flux of the many, and Chandrasekhar chooses the one as Hero, the other as Heroine. He justifies that the compositions which, however sublime may be, are bereft of oblation to the Lord of the Universe, are forsaken by the good and the honest (*Ya tadrikta suprktapica subhagapadai styajyate sadviresa*, *S D* 23/1). If it seems to us to be situated on heights far beyond our reach, yet they are the heights of our own existence. We are capable of inferring, extrapolating, and realising the Truth. It is the algorithmic and arithmomorphic verses of the *Siddhantas* that help us here for they contain the mental furniture of the divine and immortal supermind. We can see through these frames the conception of this supermind as a vastness beyond the ordinary firmaments of our consciousness in which truth of being is luminously one with all that expresses it and inevitably assures the truth of vision, formulation, arrangement, world, act and movement, and also therefore truth of result of movement, result of action and expression, infallible ordinance or law.

Chandrasekhar has quoted twenty verses from the *Surya Siddhānta* in order to show the intermediary role of the supermind (*S D*, 18/3–22), the gist of which can be enumerated in the words of Sri Aurobindo as follows:

> Above, the formula of the one eternally stable and immutable; below, the formula of the many which, eternally mutable, seeks but hardly finds in the flux of things a firm and immutable standing point; between, the seat of all trinities, of all that is biune, of all that becomes many-in-one and yet remains one – in-many because it was originally One that is always potentially many. This intermediary term is therefore, the beginning and the end of all creation and arrangement, the Alpha and the Omega, the starting point of all differentiation, the instrument of all unification, originative, executive and consummative of all realised or realisable harmonies. It has the knowledge of

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> the One, but is able to draw out of the One its hidden multitudes; it manifests the many, but does not lose itself in their differentiations. And shall we not say that its very existence points back to Something beyond our supreme perception of the ineffable Unity; Something ineffable and mentally inconceivable not because of its unity and indivisibility, but because of its freedom from even these formulations of our mind; Something beyond both unity and multiplicity? That would be the utter Absolute and Real which yet justifies to us both our knowledge of God and our knowledge of the world.
>
> R F, *The Life Divine*, 1986, p.126

The personalisation of God (*Vasudevah parambrahmā tanmurtih purusahparah*, etc. *S D*, 18/4–22) in ancient Indian cosmology included the conception of a divine celestial lawgiver imposing ordinances on non-human nature; and the highest spiritual being known was the Creator. Order in nature was always there and it was an order ordained by a rational personal being and hence there were all-out effort that other personal rational beings would be able to spell out in their own earthly languages the divine code of laws which he had previously formulated. Of course, it cannot be contended that all deeply religious men like Chandrasekhar have believed in such a personalised God, but it may be contended that the religious attitude essentially involves emotions and states of mind which have only a point and sense as directed towards a being conceived as having attributes which can only be thought of as personal. Love, adoration, gratitude, devotion, etc., are all parts of the normal religious attitude to God, and they are all states of mind which imply essentially as their object a being having at least consciousness and the capacity for deliberate benevolence. It is not that a man like Spinoza who had no place for the doctrine of the personality of God was not religious, but only that he was inconsistent in

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adopting an attitude, which was not in accord with his metaphysics. Similarly, it cannot be said that Chandrasekhar was a bad astronomer because he had heavily dropped upon the hypothesis 'God exists' and that too in a personal manner. Only this much can be said that his as tronomy was inconsistent with his philosophy which had admitted a personal God, a God as much localised as Lord Jagannāth of Puri. To the belief in a personal God it is objected that God must be conceived as so much above us that we cannot reasonably apply to him such a category as personality, involving as it does, in the only forms in which we know it, limitations incompatible with deity. The difficulty about this is that, if we do not think of God in personal terms, there is no higher category in terms of which we can think of Him, and so we shall not be able to form any conception of Him at all, or else think of Him as a sort of non-conscious force, which will make Him sub -personal rather than super-personal. We may say that to think of God in personal terms, as Chandrasekhar has done in his *Siddhānta Darpana* (Chapter 23 has entirely been devoted in this respect) is the least misleading way we have regarding His thought.

The trend of modern thought is, however, directed towards the disbelieving of the personality; it sees, through the complex facts of existence, only a great impersonal force, an obscure becoming, and that works out through impersonal forces and impersonal laws, while personality presents itself only as a subsequent, subordinate, partial, transient phenomenon upon the face of this impersonal governance. But ancient Indian thought starting from quite the opposite direction had arrived on most of its lines at the same generalisation:

> *Rtena rtam apihitam dhruvam... dasa sata saha tasthus tad ekam.*
>
> Rig Veda, V. 62.1

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> There is a firm truth hidden by truth... there the ten hundred rays of light stand together; that is one.

Our conception of the infinite is shapeless but everywhere we see shape and shapes surrounding us and it can be and is affirmed of the Absolute One that he is at once form and the formless. The coexistence of the infinite and the finite, which is the very nature of universal being, is not a juxtaposition or mutual inclusion of two opposites, but as natural and inevitable as the relation of the principle of light and fire with the suns. As Sri Aurobindo argues:

> For here too the apparent contradiction does not correspond to a real opposition; the Formless is not a negation of the power of formation, but the condition for the Infinite's free formation: for otherwise there would be a single form or only a fixity or sum of possible forms in a finite universe. The formlessness is the character of the spiritual essence, the spirit substance of the Reality; all finite realities are powers, forms, self-shapings of that substance; the Divine is formless and nameless, but by that very reason capable of manifesting all possible names and shapes of being. Forms are manifestations, not arbitrary inventions out of nothing; for line and colour, mass and design which are essentials of form carry always in them a significance, are, it might be said, secret values and significances of an unseen reality made visible; it for that reason that figure line, hue, mass composition can embody what would be otherwise unseen, can convey what would be otherwise occult to the sense. Form may be said to be the innate body, the inevitable self-revelation of the formless, and this is true not only of external shapes, but of the unseen formations of mind and life which we seize only by our thought and those sensible forms of which only the subtle grasp of the inner consciousness can become aware.

The Life Divine, p.338

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To express this idea with any nearness an idol had to be created which would be at once intuitively metaphysical and revealingly symbolic, admitting significant and living cultural patterns as the vehicle of a close, suggestive, and vivid indication – an idol such as we find carved out into a subtle and impregnated massiveness in the cult of Lord Jagannāth, the only of its kind in the whole length and breadth of India. His exoteric form may seem at first sight to be an original anthropomorphism terminating in an intellectual notion of the deity, but where the inner sense of the spiritual things has become clearer, the veridical idol assumes the appearance of personality of the one divine, as is the declared point of view of the *Purusa Sukta*:

> *Purusa*, who has a thousand heads, a thousand eyes, a thousand feet, investing the earth in all directions, exceeds (it by a space) measuring ten fingers.
>
> *Purusa* is verily all this (visible world), all that is, and all that is to be; he is also the lord of immortality; for he mounts beyond (his own condition) for the food (of living beings).
>
> Such is his greatness; and *Purusa* is greater even than this; all beings are one-fourth of him; his other three -fourths, (being) immortal, (abide) in heaven.
>
> Three-fourths of *Purusa* ascended; the other fourth that remained in this world proceeds repeatedly and, diversified in various forms, went to all animate and inanimate creation.
>
> From him was born *Virāj* and from *Virāj Purusa*, he, as soon as born, became manifested, and afterwards (created) the earth (and) then corporeal forms.
>
> When the gods performed the sacrifice w ith *Purusa* as the offering, spring was its ghee, summer the fuel, and autumn the oblation.
>
> They immolated as the victim upon the sacred grass *Purusa*, born before (creation); with him the deities who were *sādhyas* and those who were *rsis* sacrificed.

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> From that victim, in whom the universal oblation was offered, the mixture of curds and butter was produced, (then) he made those animals over whom *Vāyu* presides, those that are wild, and those that are tame.
>
> From that victim, in whom the universal oblation was offered, the *Rgs* and *Sama* were produced; from him the metres were born; from him the *Yajuh* was born.
>
> From him were born horses and whatsoever animals have two rows of teeth; yea, cows were born from him; from him were born goats and sheep.
>
> When they immolated *Purusa*, into how many portions did they divide him? What was his mouth called, what his arms, what his thighs, what were his feet called?
>
> His mouth became the Brāhmana, his arms became the Kshatriya, his thighs became the Vaishya; the Sudra was born from his feet.
>
> The moon was born from his mind, the sun was born from his eye; Indra and Agni were born from his mouth, *Vāyu* from his breath.
>
> From his navel came the firmament, from his head the heaven was produced, the earth from his feet, the quarters of space from his ear, so they constituted the world.
>
> Seven were the enclosures of the sacrifice, thrice seven logs of fuel were prepared, when the gods, celebrating the rite, bound *Purusa* as the victim.
>
> By sacrifice the gods worshipped (him who is also) the sacrifice; those were the first duties. Those great ones became partakers of the heaven where the ancient deities the *sādhyas* abide.
>
> Rg Veda, X.90

If we subject these notions of the divine personality to the discrimination of the intellect, we shall be inclined to reduce them, according to our bent, to fictions of the imagination or to psychological symbols, in any case, the response of our sensitive personality to something which is

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not this at all, but is purely impersonal. Also, that is in reality the very opposite of our humanity and our personality and therefore in order to enter into relations with it we are impelled to set up these human fictions and these personal symbols so as to make it nearer to us. So says Sri Aurobindo (*The Synthesis of Yoga*, p.55 9). But nowhere in India but at Purusottama Ksetra popularly known as Puri, this Vedic iconography symbolising the supreme *Purusa* had been so successfully enshrined. Samkara, in his *Saparyā hrdaya* explained the significance of the worship of *Purusa* – in the seventh and last verse of the monograph:

> *Puruso bhagavān ihopahārah prakrtih kālatanuh svayam ca kartā havanādisu sādhyatā ca kartuh phalabhaktvena bhavatyu pādhibhedāt.*
>
> Qf. *The Cultural Heritage of India*, vol. IV, p.461
>
> *Purusa*, (from *pālana-puranayoh*, that which pervades and fills up everything) the all-pervading, Himself is Bhagavat or the deity conceived as endowed with qualities *sadgunya paripurito bhagavan* – the six qualities are: (i) absolute greatness (*māhatmya* or *aisvarya*), (ii) holiness and power (dharma and *virya*), (iii) renown (*yasas*), (iv) beauty (*sri*), (v) knowledge (*jñāna*), and (vi) detachment (*vairagya*) or will or desire (*kāma*) or action or effort (*prayatna*).

This means that the all-pervading Absolute is itself the Deity fit for worship, when qualities are ascribed to it. Prakrti or manifested nature forms the materials with which it is to be worshipped. The worshipper himself is no other than the Absolute in the shape of time, that is, as limited by time. The esotericism of the *upacāras* is to conceive the return of the manifested universe to the unmanifested homogeneous unitary state, which is the Absolute, as a result of the effect of time which itself is eternal and absolute. In its exoteric form, this truth assumes the shape of the offering of the five fundamental forms of existence and becomes the *pancopacāra*. (Ibid.)

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Not only Samkara but Yamunacharya, the founder of the system of *Visistādvaita* also, in his *Mahāpurusa-nirnaya* proved the supremacy of Visnu, who he held, is the *Mahapurusa* of the *Purusa Sukta*, the essence of the Vedas (Ibid., p.174). Apart from these philosophical bearing Chandrasekhar had other solid grounds to accept Lord Jagannāth astronomically as the Lord of the Universe. In mythology, the *Vedic Purusa* had also been depicted as the *naksatra purusa* (*Matsya Purana*, Ch. LIV) or 'Stelliferous Person' which had been duly incorporated by the foremost astrologer and astronomer Varāhamihira (c. AD 600) in his *Brhat Samhitā* (VIII. 105) and *Brhajjātaka* (I.4.) Throughout the history of the Hindu religion, symbols and forms and personalistic conceptions of divinity have played an important part in matters of worship and astronomy has been nevertheless complementary. The hymnology within the treatise of astronomy like Chandrasekhar's *Hymn to Purusottama* (Ch. 23/ *S D*) is not to be taken as an unnecessary appendix. Rather it is the crux of the matter. Chandrasekhar has always been aware that the 'Huge Log of Wood' is not a mere log of wood, as in the case of Baudelaires symbolism; objects are not simply objects but are the symbols of ideal forms lying concealed behind them. Though made up of natural objects, the symbol of the Lord of the Universe corresponds to the supernatural 'Person' whose greatness can only be comprehended by the Vedas and Upanisads. He has therefore, expressed great concern about using earthly imperfect objects in the similes meant for the Lord of the Universe lest his greatness should be vulgarised:

Drabyairjātupamanam nabhavatikrtinā
Prākrtairjātadosam
Sarbāntaryāmibhāvāddyutimatikrtibhih
yasya lokottarasya
Vyaktāvyaktesusatve svaparimitanija
Vyāpti mudvyaktakāmah

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Stasmādo divyasimho' bhavadihaca mahādāru
dehaḥ sa no' vyāt.

S D, 23/19

Dr John Oman, in his *The Natural and the Supernatural*, states that 'reconciliation to the evanescent is revelation of the eternal', and Canon Raven, in his *Science, Religion and the Future*, applauds Dr Oman for having stated the principles of theology in which there could be no ultimate antithesis between nature and grace, science and religion, in which indeed the world of the scientist and the theologian are seen to be one and the same. So has done our Chandrasekhar.

Fictions and their use in rational discourse have become one of the important aspects of philosophy since the publication of Voihinger's *Philosophie des Als – Ob (Philosophy of the As – if)* and metaphors (or similes) which occur especially in general explanations of large groups of events are among such fictions. Prof. S C Pepper has classified them, in his *Word Hypotheses*, as metaphors of mechanism, formism, organicism and contextualism. George Boas, Emeritus professor of philosophy at Johns Hopkins University (1961), has stated that the number of basic metaphors is not limited to four and that a scientist or philosopher may adopt any figure of speech which he finds illuminating and use it as widely as he chooses. He has shown how the notion of polarity, obedience to universal law, the notion of the universe serve as basic metaphors ('Basic Metaphors', Ch. 3, *The Limits of Reason*, Routledge and Kegan Paul, 1961, pp.71–99). Prof. Boas has said:

> At the present time we are in a situation where the conclusions of the Sciences, especially those of physics, demand new figures of speech from the philosopher and the philosopher either throws up the sponge, turns the

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> problem over to the poets, or says that the problem is meaningless. It is true that one cannot verify a figure of speech. We may fill its adequacy, but its nature is not such as to assert much of anything. To verify it would demand that it loses its metaphorical character. But if we could translate it into literality, we would not need it at all.
>
> Ibid., p.94

Perhaps under the same impression Chandrasekhar had adduced four basic metaphors in order to describe his God such as (i) the metaphor of the universe (*S D*, 23/23), (ii) the metaphor of the ocean (*S D*, 23/21/22), (iii) the metaphor of the sun (*S D*, 23/28) (iv) the metaphor of the planets (*S D*, 23/29). It was very well known to him that God could not ostensibly be defined save these metaphors. With Juliana of Norwich it might be said: 'Wherefore in the eternal justice, such sight as your earth receives is engulfed, like the eye in the sea; for though by the shore it can see the bottom, in the ocean it cannot see it; yet nonetheless the bottom is there, but the depth hides it' (Cf. *The Perennial Philosophy*, p.246). Also as Aldous Huxley has added – 'Love is the plummet as well as the astrolabe of God's mysteries, and the pure in heart can see far down into the depths of the divine justice, to catch a glimpse, not indeed of the details of the cosmic process, but at least of its principle and nature.' Chandrasekhar's insights permit him to say:

> *Yo'sau sarvatrapurno' pyasitagiridari*
> *Kesari tho' pya rupah*
> *Padma pradyumna rupo' pyanuratanutatanu*
> *Sambhrtāsesalokah*
> *Nistraigunyo 'ganyāpya malagana nilayo*
> *Bagmano tita dhāma*
> *Mādrkcarnaksilaksah sphuratu manasa*
> *nascitra sindhurmukundah.*
>
> S D, 23/43

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> Let the Lord, the Ocean of Wonder, be perceptible to my skin eyes. Unfathomable though by words or minds, indeterminate though, he is the abode of all attributes. Though smaller than the infinitesimal, He contains the universe within Himself. Formless though He manifests himself in numerous incarnations. He pervades the entire space time but in the cave of the Blue mountain he is domiciled like a lion.

When we think of the world as a continuum, traditional syntax and vocabulary seem to be quite inadequate. Mathematicians have therefore invented different symbol-systems. But the divine ground is not merely a continuum. It is also out of time and space to which traditional language and the language of mathematics are adequate; hence in such expositions as quoted above, the frequency of paradox, of verbal extravagance. It is a spiritual calculus in terms of which we may talk coherently about the divine existence and of the world conceived as its manifestation. The so-called Euler-Diderot incident in 1773 illustrates how the atheist's libellous tongue was quietened. It was once arranged that the atheist Diderot should meet the Russian philosopher, learned mathematician, and distinguished member of the Russian Academy, who was prepared to prove to him the existence of God, algebraically, and before the whole court (a project, by the way, continued by the mathematical genius, Kurt Gödel). The occasion arrived, the whole court was present, and the Russian philosopher Euler advanced seriously towards Diderot and spoke in an earnest voice, full of conviction, 'Monsieur, $(a+b^n) / z = x$. Therefore God exists. Answer that.' Diderot, though unmatched in his own intellectual domain, was not Euler's equal in mathematics, and so withdrew from the contest. (*Catching the Light*, p.113)

Chandrasekhar's mathematical temperament, like Euler's, led him to pursue an alternative description of

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phenomena that created a more abstract imagination of nature through the application of mathematics. On the basis of his observations he fashioned a purely mathematical astronomy of amazing precision. Still, significantly, he completely lacked any picture of the cosmos other than that provided by religious mythology. He used two languages to discuss the nature of our world. One appeals to our sensual imagination, the other to abstract reasoning.

Matsādyā kalkirupam dasavidhatanubhāk
Siddhasamkhyātma murtid
Dvātrimsad gātradhartā jagadupakrtayet
krptanānāvatārah.

S D, 23/41

The doctrine, that when goodness grows weak, when evil increases, God himself takes a body and that in every age He comes back to deliver the holy, to destroy the sin of the sinner, to establish righteousness, is found in most of the principal historic expositions of mankind. As Suso has expressed:

> All creatures have existed eternally in the divine essence as in their exemplar. So far as they conform to the divine idea, all beings were, before their creation, one thing with the essence of God. (God creates into time what was and is in eternity.) Eternally, all creatures are God in God... so far as they are in God, they are the same life, the same essence, the same power, the same one, nothing less.

Cf. *The Perennial Philosophy*, p.68

Aldous Huxley has rightly commented upon that every individual being, from the atom up to the most highly organised of living bodies and the most exalted of finite minds may be thought of thus as a point where a ray of the primordial Godhead meets one of the differentiated,

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creaturely emanations of that same Godhead's creative energy. The creature, as creature, may be very far from God, in the sense that it lacks the intelligence to discover the nature of the divine ground of its being. But the creature in its eternal essence – as the meeting place of creatureliness and primordial Godhead is one of the infinite number of points where divine reality is wholly or eternally present. (Ibid., pp.70–71)

Samanta Chandrasekhar, in his *Hymn to Purusottama* has corroborated the ideas which Jayadeva (c. AD 1200) had postulated in his famous work *Gita Govinda*, that his hero of the testament is in fact the incarnation of all incarnations (*Vedavadyo' vatāri*, *S D*, 23/42) starting from the primordial Fish to ever-impending *Kalki*. It is because of the fact that all avataras have biographies, or historical accounts, and biographical or historical facts make them quasi -divine. But Lord Jagannāth has no biography, no parentage, and therefore represents, more than any other incarnation, the Supreme Person, the Absolute Divine.

> *So' kāmayat, bahusyām prajāyeyeti sa tapo' tapyata*
> *Sa tapantaptvā idam sarvamasrjat yadidam kim ca.*
>
> *Taittiriyopanisad* 11.6

> He desired: 'Let me be many, let me multiply.' He reflected, and after reflection, He projected all this – whatever there is. Having projected it, He entered into that very thing, and became the gross and the subtle.

The *Mundakopanisad* says: 'As a spider projects and withdraws its web, as herbs grow on earth, or hair comes on a living person, so does this universe here proceed from the Immutable.' (1.1.7)

All the universes co-existing in space and succeeding each other in time, the planes of being and the creatures of

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those planes, whether natural or supernatural, are manifestations from the inexhaustible, original and eternal well of being, and are made manifest by a play of māyā, the supreme power that generates and animates, and display the dynamic aspect of the universal substance. It is personified as the world – protecting, feminine, maternal side of the Ultimate Being and as such, stands for the spontaneous, loving acceptance of life's tangible reality – she is the Eternal Feminine.

Thus *Purusa* and *Prakrti* are the archetypal parents in the form of Father Heaven and Mother Earth. Chandrasekhar quotes from the *Surya Siddhānta*: 'As part of the Absolute Brahmā, Samkarsana adopted body form and entered into the womb of nature. He is all-pervading but nonetheless knowable. First of all he created water (*āpah*) and inseminated it.' (*S D*, 18/5)

When the divine life substance is about to put forth the universe, the cosmic waters grow a thousand-petalled lotus. This is the door or gate, the opening or mouth of the womb of the universe. It is the first product of the creative universe. It opens to give birth first to Brahmā, the demiurge creator. From its pericarp then issue the hosts of the created world. According to the Hindu cosmogony, the waters are female; they are the maternal procreative aspect of the Absolute, and the cosmic lotus is their generative organ. The cosmic lotus is called the Goddess Earth. It is personified as the Mother Goddess through whom the Absolute moves into creation: *sribhuliladi sevyodar Kamala gada cakrabhrd venupanih.* (*S D*, 23/44)

This goddess Lotus, the ageless Mother Earth, the Magna Mater of Antiquity, procreative energy and fortune on the physical plane has been transfigured under the aspect of *Bhudevi* and *Sridevi*, the beloved spouse of the Lord of the Universe. Though the goddess, as the supreme divine māyā (*maya payadapayadaya muditadayah pundarikeswaro's man*: *S D* ,

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23/52), assumes of form and plays a part in the cosmic drama of the universe and playfully enacts the leading role at a great climax of the celestial stage, nevertheless, she behaves as someone might who was playing the role of hero in his own creation, fully aware that he is keeping his eyes ever open. Fundamentally and consciously, this presence remains totally unconcerned with her own playful manifestation. Her splendid countenance, vigorous and graceful, is so amazing in this respect that the Hero's eyes remain ever unblinking. The plenary plot of their play is the subject matter of ancient *Siddhantas* and Chandrasekhar was not so indisposed to give up the holistic approach which had connected earth and heaven, man and God.

This Earth, the Theatrical Queen of the firmament who cradles all our mighty designs, all our navigations, might be inconsiderable when we compare it with the vast orbs of the galaxies of the universe, but it still enjoys the unique position as the only living planet. There are not yet any obvious signs of extraterrestrial life and this makes us orthodoxically believe that the universe has only two entities. One is the Mother Earth and the other is the rest of the universe, or the Father Heaven. As the Vedic myth-makers knew, we are the children of the Sky and the Earth. They are the archetypal parents, themselves the first-born of the pairs of opposites, first bifurcation of the primal, cosmogonic reality. Under the form of Father Heaven and Mother Earth, they were known to the Greeks as Zeus and Hera, to the Chinese as T'ien and Ti, Yang and Yin, and to the Vedic people as *Dyāvā-Pṛthivi*. Their sacred marriage is multifariously figured in the various traditions of the world mythology. There are various ways of representing the differentiation of the Absolute into antagonistic yet cooperative pairs of opposites but the oldest and most usual of these is the one based on the duality of the sexes. Even in the astronomical works, this archetypal pattern was ever

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present. So says Samanta Chandrasekhar: *Dhamne syama dharadharadhipataye kasmai cidasmai namah* (S D, 2/25) ('I worship the Lord of this Mother Earth.')

The playful manifestation of the conjugality of *Dyāvā-Prthivi* was then the subject matter of astronomical literature of the ancient seers. Predictable change in nature, where things changed according to the patterns, rules, or as we call them, laws of nature, was the impetus for this scientific pursuit. The continuous alternation of day and night was perhaps the most interesting p henomena which had attracted the attention of our ancestors giving rise to a host of legends, myths, and symbols. In the Rg Veda, Dawn (*Usā*) the daughter of Heaven and her sister Night (*Nisā*), have been depicted as the obverse and reverse sides of the same eternal infinite: *Dyāvā-Prthivi*. This was further developed into the astronomical myth of Sun's marriage to *Sajnā* (dawn) and *Chhāyā* (shadow or Night). Dawn is the daughter of Heaven who is the primordial Father God, hence the phenomenon was incorporated in the legend of Prajāpati's incestuous passion for his daughter (R V, X.61; *Aitareya Brāhmana:* III.33; *Satapatha Brāhmana*: 1.7.4.1). That the legend is ingrained with astronomical phenomenon has been recognised by eminent astronomers. For example, P C Sengupta explains the myth:

> The astronomical phenomenon was observed in mid-heaven or on the meridian of the observer. We have a star called *Prajāpati* in the *Surya Siddhānta*, viiii. 20, which is identified by Burgess in his translation, with δ Aurigae, and his identification is faultless. We also have the *Mrgavyādha* (Sirius) of which another Vedic name was Svān (or the Dog), and *Rohini* is of course the star Aldebaran. The legend divested of allegory is that the stars δ Aurigae and α Tauri or Aldebaran were observed to cross the meridian almost together. This was understood by the

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gods as the most improper conduct on the part of Prajāpati, and the God Rudra, then born and stationed at the star Sirius, pierced Prajāpati (δ Aurigae); his three-pointed arrow was most probably the line through θ β δ Aurigae, which have almost the same celestial longitude. Again the star Sirius, the three stars at Orion's belt and α Tauri or Aldebaran are very nearly in the same line. Here Rudra's three pointed arrow may also mean this latter line through Orion's belt.

Ancient Indian Chronology, p.149

This shows how over the dying embers of the sacrificial fire, our ancestors watched the conjunction of stars and thought of the phenomenon in terms of conjugal love. Regarding the solstice days we find:

Rohito dyāvā prthivi jajāna tatra tantum paramesthi tatāna/tatra sisriye' ja ekapād o' ddrhad dyāvā prthivi valena.

Atharva Veda: xiii, 1.6

The ruddy one generated heaven and earth, there the most exalted (*paramesthin*) stretched the line (*tantu*); there was supported the one- footed goat (*aja-ekapada*); by strength he made firm heaven and earth (tr.) Whitney.

According to P C Sengupta the above sloka has clearly an astronomical interpretation. The word *aja-ekapada* clearly means the *naksatra Purvabhādrapada* for which the chief star (junction star) is α Pegasi, and the word *tantu* (line) refers to the winter solsticial colure. *Rohita* (the ruddy one) undoubtedly means the ruddy sun. (*Prosthapada naksatramajaekapaddevata*, *Taittiriyasamhitā*: vi. 4.10; *T Brahmāna*: 1.5.1) (*Ancient Indian Chronology*, p.96)

The Rg Veda refers to a solar eclipse in the following manner:

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When O Surya, the son of Asura Svarbhānu overspread thee with darkness, the worlds were beheld like one bewildered not knowing his place. When, Indra, thou wast dissipating those illusions of Svarbhānu which were spread below the sun, Atr i, by his fourth sacred prayer, discovered the sun concealed by the darkness impeding his functions.

R V: V. 40, 5–6

In India, astronomy is not merely a collection of numbers and mathematical equations; it is a collection of words and sentences chosen, from others that were poetically just as good, because they described a world connected with sensual experience. The vocabulary of Indian astronomy is wider if we consider it as a body of propositions deriving truth from observation. It speaks of the cohabitation of Nature. For example:

Evam Suryagrahane grāhyo Ravih, grāhakascandrah. Uktalaksane tayoh purvāpara yāmyottarāntarabhāvah. Atastada ravicandrau sarvāmsatayā samau bhavatah. Paranca Ravikaksātcandrakaksāyā adhogatatvāt suryagrahane candro ravi bhu bimboyormadhyagato bhavati. Idanim bhupradesastha lokānām drstipathagata krsnanscandro Ravidarsane bādhako bhavati. Ato' dhogata candrabimbenācchāditasya ravibimbasyadarsanādravigrahanam. Iyam samsthā 'darsah suryendusamgamah' ityukteh darsānte bhavati.

Surya Siddhānta, Ch. 4, Introduction, Kapileswar Shastri, p.138

The solar eclipse is a cohabitation of the sun and the moon. The moon is the conceiver and the sun is the conceived. Sripati and Bhaskara have even imagined that the shadow of the moon is the tuft of hair of the lady whose face is being kissed by the sun: '*Taranikiranasamgādesa piyusa pindo dinakaradisicandrascandrikābhiscakāsti/Taditara disivālā kuntalasyāmalasri rghata iva nijamurtichāya yaivātapasthah.*' (*Siddhānta Śiromani*, Golādhyāya, Atha Srngonnati Vāsana. 1, p.436, cf. *Siddhānta Sekhara* Adhyaya 1. Sloka 2)

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Likewise, the conjunction of anyone of the five star-planets with the moon has been termed as *samāgama* (S S/S D, 11/2) which means copulation. In mythology the moon is considered as the husband of the twenty-seven stars of the zodiac and it lives with one star each day. Not only love making, but astronomical phenomenon has also been described as war if it is a conjunction between two planets. Their victory and defeat, according to calculations, cast considerable effect on terrestrial life.

The elevation of lunar horns (*Candra -Srngonnati*) (*S D*, Ch. 14) as described in Indian astronomical works corresponds and corroborates with the rules of love formulated by Vatsayana and with the *srngāra rasa* of the Indian poetics. As has been said by Viswanāth Kavirāja:

Srngam hi manmathodbhedastadāgamanahetukah
Uttama prakrtiprāyorasah srngāra isyate.

Sāhitya Darpana, 3/183

'*Srngam rcchati iti srngāra.*' *Srnga* is the device by which the beloved and the lover are pierced and *srngāra* is the *rasa* which is created in their being pierced by the horns of eroticism or *kāma*. The moon, as people still believe, controls the tides of the ocean, the life cycles of many animals and plants and the human menstrual period.

In the said Rg Vedic verse (V. 40.8), Atri has been alleged to have found out the instant of the end of eclipse by counting stones: 'Then the Brāhmana (Atri), applying the stones together, propitiating the gods with praise, and adoring them with reverence, placed the eye of Surya (sun) in the sky; he dissipated the delusions of Svarbhānu.' This practice of counting stones had been continued even up to the time of Prthudaka (AD 864) (*Ancient Indian Chronology*, pp.103–104) and shows how the ancient seers were keen about

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predicting natural phenomena. This rudimentary practice had given rise to a special branch of Vedic knowledge called *Vedanga Jyotiṣa*.

'Why did people all over the world make such an effort to learn astronomy?' asks Carl Sagan and thinks it was because they had seen in the skies a great calendar, available to anyone with dedication and ability and the means to keep records (*Cosmos*, pp.33–34). As scientific knowledge aims at being wholly impersonal and tries to state what has been discovered by collective intellect of mankind, pure mathematics made inroads into concepts of poetic extravaganza. Because mathematics works in a manner which is capable of stating reality impersonally. The practical utility of science depends upon its ability to comprehend the past and to foretell the future. The enigma of birth and death has ever been thought of as predestination. 'The question of questions for mankind – the problem which underlies all others and is more deeply interesting than any other – is the ascertainment of the place Man occupies in nature and his relations to the universe of things' (T H Huxley quoted in *Space, Time and Man*, p.106). And from early times people have been aware, in spite of their limited perceptions of space and time on earth, that they had only to look to the heavens to get the answer. The notion that human fate was ultimately controlled by conjunctions of the heavenly bodies, played its part but with mathematical precision. Thus every aspect of human misery and happiness was extrapolated as the result of celestial configuration. The beauty of the heavens, to them, was not only visual but also moral and intellectual. In the pursuit of identifying themselves in the backdrop of a limitless universe they had figured out a number of mathematical formulae or rules such as: *Jya* (sine), *Kotijyā* (cosine), celestial coordinates (latitude and longitude, right ascension, and declination), anomaly (*mandakendra* or *sighrakendra*), apogee or aphelion

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(*mandocca*), apse line (*nicoccarekhā*), ascending node of the moon (*Rahu*), celestial latitude (*ksepa*, *viksepa*, *sara*), celestial meridian (*yamyottara mandala*), co-azimuth (*digamsa*), co-latitude (*lamba*), declination (*kranti*), ecliptic (*krānti vrta*), epicycle (*nicocca vrta*), equation of centre (*mandaphala*), equation of conjunction (*sighraphala*), equinox (*krāntipāta*), hypotenuse (*karna*) meridian zenith distance (*avanati*), parallax in latitude (*nati*), parallax in longitude (*lambana*), perigee (*mandanica*), polar longitude (*dhruvaka*), pole of the celestial equator (*dhruva*), precession of the equinoxes (*ayanāmsa*), solstice (*ayanānta*), zenith distance (*natāmsa*), *ahargana* (sum of civil days elapsed on a given day since a chosen epoch), *agra* (*amplitude*, i.e. the arch along the celestial horizon lying between the east point and the rising point of a heavenly body), *agrajyā* (R Sine of amplitude), *aksāmsa* (terrestrial latitude), *aksa valana* (angle subtended at a heavenly body on the ecliptic by the arc joining the north pole of the celestial horizon), *bhagana* (revolution of a celestial body in a long period of time), *bhuja* or *bāhu* (base of a right-angled triangle for an angle Ø), *bhujāntar* (correction for the equation of time due to the eccentricity of the orbit), *cara* (arc on the celestial equator between 6 o'clock circle and the hour circle of a heavenly body at rising), *cara samskāra* (correction to the mean position of a heavenly body due to the difference between instants of midnight at Lanka and the given place), *chandrakalā* (one-sixteenth of the moon's disc), *desāntara* (difference in longitudes of a given place and the prime meridian, usually Ujjain), *daksināyana* (southern course of the sun), *uttarāyana* (northern course of the sun), *kadamba* (pole of the ecliptic), *kadambaprota* (secondary to the ecliptic), *karana* (half of a lunar day), *koti* (perpendicular), *krāntipāta* (equinoxes, points of intersection of the ecliptic and the celestial equator), *lagna* (ascendant, orient ecliptic point, point of intersection of the ecliptic with the eastern horizon), *mandakarma* (finding the equation

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of centre), *natakālajyā* or *natajyā* (Radius, sine of the hour angle), *natakālakotijyā* (Radius, cosine of the hour angle), *niraksa* (earth's equator, zero latitude), *samamandala* (prime vertical), *samāsa vrtta* (circle of radius equal to the sum of the radii of the eclipsing and the eclipsed bodies), *samkrānti* (solar ingress into a sign of the zodiac), *sighrakarma* (finding out the equation of conjunction), *sighrakendra* (angular distance of a mean planet from its *sighrocca* or apex of conjunction), *tithi* (lunar day one-thirtieth of a lunar month), *tribhonalagna* (non-agesimal point, point of the ecliptic at the shortest distance from the zenith; 90° less than *lagna*), *udayāntara* (complementary to the *bhujāntara*, the correction to the celestial longitude on account of the equation of time due to obliquity of the ecliptic), *unnatakāla* (distance from the horizon in time unit, time elapsed after rising of a celestial body), *unnatāmsa* (complement of zenith distance), *unnati* (altitude), *vaidhrta mahāpāta* (the aspect between the sun and the moon when the sum of their longitudes is 360° and their declinations or *kranti* are equal in magnitude but opposite in directions), *vyatipāta* (the aspect of the sun and moon when the sum of their longitudes is 180° and their declination are same both in magnitude and direction), *vakragati* (retrogression), *visuva* (equinox), *vitriva lagna* (lagna – 90°), *caradala* (ascensional difference) etc.

This list of technical terms of Indian astronomy speaks, to some extent, of the pose and posture of the creator and the creatrix who are always in the postscenium of the universe. The deep and difficult concepts needed to fathom the depths of nature's structures are made up, step by step, from very simple concepts like counting fingers and toes. It is often suspected that mathematics is so miraculously effective a tool in the understanding of nature's working that it might actually be that nature is mathematical in its ultimate nature. There appears to exist patterns of behaviour

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from which the universe of our experience has never deviated. If there were no patterns of behaviour in the universe, the chaos that would exist could not give rise to organised structures of intelligence. It is possible only because there exist regularities in nature and awareness in men that they are embodiments of theories about the laws of nature drawn from the part of nature that they have encountered. The concept of modern astronomy may appear superficially very sophisticated and far removed from those required to thrive in unfavourable ancient environments, but it is remarkable how, when mathematics was used to describe the patterns of nature in space and time, the results were often spectacularly successful. Samanta Chandrasekhar had once again demonstrated this characteristic excellence of mathematics, with all the overwhelming force of a revelation:

> *Jyotihsāstra phalam purānaganakairādesaityucyate*
> *Nunamlagnabalāsritam punaridam tatspastakhetā srayam.*
>
> *Tegolāsrayinontarena ganita golo'pi na jnayateh*
> *Tasmāt yo ganitam na bettisa katham golādikam jnāsyati.*
>
> S D, 16/10
>
> Ancient astronomers have termed the results of astronomy as commandment or revelation. It depends upon the knowledge of *lagna*. *Lagna* depends upon the position of planets. Without the knowledge of the true positions of planets, revelation cannot be made on the basis of *lagna* only. Planets move on the celestial sphere. Hence, celestial sphere must be studied for calculating the true positions of planets. Celestial sphere can only be studied by means of mathematics.

J Hadamard (1945) has made in his *The Psychology of Invention in the Mathematical Field* (Princeton University Press), one of the major points in his study of creative thinking so as to

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refute the thesis that verbalisation is necessary for thought. A quotation from the letter he received from Einstein on the matter may be reproduced here:

> The words or the language, as they are written or spoken, do not seem to play any role in my mechanism of thought. The psychical entities which seem to serve as elements of thought are certain signs and more or less clear images which can be 'voluntarily' reproduced and combined... The above-mentioned elements are, in my case, of visual and some muscular type. Conventional words or other signs have to be sought for laboriously only in a second stage, when the mentioned associative play is sufficiently established and can be reproduced at will.
>
> Cf. *The Emperor's New Mind*, p.548

No more justification is needed for Samanta Chandrasekhar's creative thinking which has sought for conventional words and other signs to reproduce the established associative play of his psychical entities in witnessing the wonder of the heaven.

> *Bhacakra lokato loka srastulokottarakrti.*
>
> S D, 21/205

> Looking at the celestial sphere, people can imagine the wonders of the Creator.

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Chapter X

INSTRUMENT VERSUS FREE WILL

Man is a tool-making animal.

Hector Hawton, *Reason in Action*, p.9

'The *Rsi*, the *Hotri*, our father who offering all these words has taken his seat; desiring wealth by pious benedictions, the first inventor has entered inferior (beings). What was the station? What was the material? How was (it done) so that the beholder of all, Visvakarman (was) generating and disclosed heaven by his might.' (Rg Veda, X.81: 1–2)

Man is of course a tool-making and tool -using animal; but if we dwell too much on this characteristic we are in danger of overlooking something that has played just as significant a part in human history – the inextinguishable curiosity which has led to the birth of magic. It was a curiosity to know how to create anything without the help of instruments. If God has created the universe, certainly He had not used any tool. But man, being inferior to God, could not do anything without manipulating tools.

Our ancestors had made a preliminary reconnaissance of a few of the heavenly bodies which were visible to the naked eye. Seven planets including the Sun and the Moon and twenty-seven stars only had stirred our ancestors' intellect. Perhaps they were aware that the creator had made it impossible for them to have any communication from this earth with the other great bodies of the universe in their present state and He had likewise cut off all communication betwixt the other planets and different systems. They

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observed enough, in all of them, to raise their curiosity, but never to satisfy it. It did not appear to be suitable to the wisdom that they should see so far, and have their curiosity so much raised only to be disappointed at the end. For them the cosmos was beyond measure. For us it is still beyond our measure. We can roughly say this much that the total number of stars in the universe is greater than all the grains of sand on all the beaches of the planet Earth. Perhaps it will be ever beyond our measure. Then to what purpose should anyone trouble himself in searching out the secrets of the heaven, having poverty and pestilence, death and slavery continually before one's eyes?

The ancient Indian astronomers' disdain for soaring high into the vastness of space and the immensity of time was due to this feeling of the impossibility. They were as much contented with their limitations as they were confident of their intuitive and transcendental powers. Instruments were never more significant than the scientism, i.e. the general philosophy which claims that all aspects of the universe are knowable through science and that science as such is th e only reasonable, adequate, and useful mode of cognition, superior to all others: '*Sresthaṃ sarva srutanaṃ srutamitikrtibhi jyotisaṃ tatra sarah...*' (*S D*, 1/18) But perhaps a principle like the uncertainty principle or undecidability principle had signalled an end to their dream of a deterministic universe. They had certainly realised that one cannot predict future events exactly as one cannot even measure the present state of the universe precisely. As Bertrand Russell has put it:

> Rough measurements lead to an approximate law; changes in the measuring instruments (subject to the rule that all instruments for measuring the same quantity must give as nearly as possible the same result) are found capable of making the law more nearly exact. The best instrument is held to be the one that makes the law most nearly exact,

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> and it is assumed that an ideal instrument would make the law quite exact.
>
> *Human Knowledge*, p.301

Awareness of this sort of insurmountable limitations which rest on the impossibility of getting at the necessary determining facts, and even of stating and integrating the differential equations of the universal formula, of mastering their boundless extension, multiplicity, and complexity, Chandrasekhar has clearly been subjected to, so as to say: 'I am not omniscient. Hence, my calculations cannot have eternal validity' (*S D*, 21/54). But, in spite of all sorts of limitations he has approximated his calculations for 10,000 years in future (*S D*, 21/55). What kind of instruments did he resort to? The only instruments of practical utility for astronomical purposes described in ancient Indian works were the sundial, the clepsydra, the armillary sphere, the gnomon, etc., and Chandrasekhar had faithfully followed Bhaskara's conclusion: 'But what does a man of genius want with instruments, about which numerous works have treated? Let him only take a staff in his hand, and look at any object along it, casting his eye from its end to the top. There is nothing of which he will not then tell: its latitude, dimension, etc.' (*S S*, XI.40)

Chandrasekhar was against using any instrument having a foreign trademark. He strongly believed that a good scientist should devise his own instrument. He was obsessed with the fact that the mercantile tradition, which had Europeanised Indian science also had led to intellectual servility. Moreover, tool-making had always been considered as a work of art. Instruments are artefacts. As the word 'artefact' implies, the thing made is a work of art, made by art, but not itself art, the art remains in the artist and is the knowledge by which things are made. By devising his own special instruments for astronomical purposes, Chandrasekhar had

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proved that, though an astronomer, he was nevertheless a master of his arts. One had better be an artist than go about loving art, just as one had better be an astronomer than go about looking vaguely at the sky.

Man's activity consists in either a making or a doing. Both these aspects of the active life depend for their correction upon the contemplative life. The making of things is governed by art, the doing of things by prudence. The artist is not a special kind of man, but every man who is not an artist in some field, every man without a vocation, is an idler. The kind of artist that a man should be, carpenter, painter, lawyer, farmer or priest, is determined by his own nature, in other words by his nativity. (*Christian and Oriental Philosophy of Art*, A K Coomaraswamy, pp.23–24)

As everyone makes use of things that are made artfully, as the designation 'artefact' implies, and everyone possesses an art of some sort, there is no necessity to explain the nature of art in general, but only to communicate a knowledge of particular arts to those who are to practise them, which knowledge is regularly passed on from master to apprentice. An integrated society of this sort can function harmoniously for millennia, in the absence of external interference. On the other hand, the avocation of innumerable people can be shattered in a generation by the withering sign of our culture; the local market is flooded by the production in quantity with which the native artist cannot compete, the avocational structure of our society, with all its guild organisation and standards of workmanship, would be undermined; the artist would be robbed of his art and be forced to find a job; until finally the heritable society would be industrialised and reduced to the level of such society as ours, in which business would take precedence over life. Western nations were feared and hated by Indians not alone for obvious political or economic reasons, but even more

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profoundly and instinctively for cultural reasons. Keeping this in mind Chandrasekhar had devoted himself to the practice of an art in the highest possible sense of educating the men about our heritage. The instruments described in his book, even in adhering to prescriptions and responding to requirements that had remained essentially the same for millennia, had reaffirmed our belief in our forefather's manner of operation, for example, the directions of the *Surya Siddhānta* for the construction of a sundial (111/1 –7) and an armillary sphere (X/1–16) may be compared with those of the *Siddhānta Darpana* (Ch. 7 and Ch. 30).

(a) On a stony surface, made water level, or upon hard plaster, made level, there draw an even circle of a radius equal to any required number of digits of the gnomon. At its centre set up the gnomon of twelve digits of the measure fixed upon; and where the extremity of its shadow touches the circle in the former and after parts of the day, there, fixing two points upon the circle, and calling them the forenoon and afternoon points, draw midway between them, by means of a fish figure, a north and south line. Midway between the north and south directions draw, by a fish figure, an east and west line and, in like manner, also by the fish figures, between the four cardinal directions, draw the intermediate directions. Draw a circumscribing square, by means of the lines going out from the centre by digits of its base lines projected upon that, in any given shadow reckoned. The east and west line is called the prime vertical (*samamandala*); it is likewise denominated the east and west hour circle (*unmandala*), and the equinoctial circle (*Visuvan mandala*). Draw likewise an east and west line through the equinoctial shadow (*visuvadbhā*); the interval between any given shadow and the line of the equinoctial shadow is denominated the measure of the amplitude (*agra*).

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(b) Let the teacher, for the instruction of the pupil... prepare the wonder working fabric of the terrestrial and stellar sphere (*bhubhagola*). Having fashioned an earth globe of wood, of the desired size, fix a staff, passing through the midst of it and protruding at either side for Meru, and likewise a couple of sustaining bonds and the equinoctial circle, these are to be made with graduated divisions of degrees of the circle. Further, by means of the several day radii, as adapted to the scale established for those other circles, and, by means of the degrees of declination and latitude marked off upon the latter, at their own respective distance in declination, according to the declination of Aries, etc, three bands are to be prepared and fastened; these answer also inversely for Cancer, etc. In the same manner, three for Libra, etc., answering also inversely for Capricorn, etc., and situated in the southern hemisphere, are to be made and fastened to the two band supporters. Those, likewise, of the asterisms situated in the southern and northern hemispheres, of Abhijit, of the Seven Sages (*Saptarsis*) of Agastya, of Brahmā, etc., are to be fixed. Above the points of intersection of that and the supporting bands are the two solstices (*ayana*) and the two equinoxes (*visuvat*). From the place of the equinox, with the exact number of degrees, as proportioned to the whole circle, fix by oblique cords the spaces Aries and the rest; and so, likewise, another band, running obliquely from solstice to solstice, and called the circle of declination (*kranti*) upon which the sun constantly revolves giving light; the moon and the other planets, also by their own nodes, which are situated in the ecliptic (*apamandala*), being drawn away from it, are beheld at the limit of their removal in latitude (*viksepa*) from the corresponding point of declination. The orient ecliptic point (*lagna*) is that of the orient horizon, the occident point (*astamgachhat*) is similarly determined. The meridian ecliptic point (*madhyama*) is as calculated by the equivalents in right ascension (*lankodayas*) for

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> mid-heaven (*khamadhya*) above. The sine which is between the meridian and the horizon (*ksitija*) is styled the day measure (*antya*), and the sine of the sun's ascensional distance (*caradala*) is to be recognised as the interval between the equator and the horizon. Having turned upward one's own place, the circle of the horizon is midway of the sphere. As covered with a casing (*vastra*) and as left uncovered, it is the sphere surrounded by *lokāloka*. By the application of wate r is made ascertainment of the revolution of time. One may construct a sphere instrument combined with quick silver; this is a mystery; if plainly described, it would be generally intelligible to the world. Therefore, let the supreme sphere be constructed according to the instruction of the preceptor. In each successive age, this construction, having become lost, is by the sun's favour again revealed to someone or other at his pleasure.

In principle, Chandrasekhar's artefact performs the task of art as has been enunciated by W Andrae: 'To make the primordial truth intelligible, to make the unheard audible, to enunciate the primordial word, to represent the archetype, such is the task of art, or it is not art.'

By way of describing the instrument he has made the celestial sphere intelligible. It is not simply making a model but is the embodiment in matter of a preconceived form of the visible part of the universe; an imitation of nature.

The appreciation of art should not be confused with the psychoanalysis of our likes and dislikes, dignified by the name of aesthetic reactions. 'Aesthetic pathology is an excrescence upon a genuine interest in art which seems to be peculiar to civilised people' (*Art and Life in New Guinea*, R Firth, 1936, p.9). The study of art, if it is to have any cultural value, ought to demand an understanding and acceptance of the whole point of view from which the necessity for the work arose; and a bringing to life in

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ourselves of the form in which the artist conceived the work and by which he judged it. A need is the primary cause of the production of a work of art. Chandrasekhar was therefore well contented with a functional art.

Question may be raised as to how the functional artist's primary act of imagination can be spoken of as 'free' if in fact he is working to some formula, specification or astronomic prescription. In fact if a man is blindly imitating a shape defined by others or already existing, he is not a free man, but only performing a servile operation, to be properly called an artist; yet it is not true that in practising an art, that has fixed ends and ascertained means of operation like that of astronomy, the artist's freedom is denied. Mechanical production by the hireling cannot be a work of art. But if he has conformed himself to the pattern of the thing to be made, actively and consciously making use of himself as an instrument, his work is nonetheless artistic. His theoretical or imaginative act is 'free' in this case because it is not assumed that he has blindly imitated any model extrinsic to himself. Rather, it is an act of expressing oneself apart from individual idiosyncrasy.

The artist works 'by art and willingly' (*per artem et ex voluntate*, St Thomas Aquinas). It is essential to him as a man to have a right will. He is normally either his own patron, deciding what is to be made, or formally and freely consents to the will of the patron, which becomes his own. As an artist Samanta Chandrasekhar was his own patron, but servant to God (*yasyecchame nija bhajanato duramu tsarya budhi...*) as Patron. It is in terms of the freely invented formal cause that we can best explain how his pattern of the thing to be made or arranged, his *Siddhānta Darpana* or his *Mānayantra* for example, was known. His operation was twofold, free and servile, theoretical and operative, inventive and imitative. It was only when the form of the

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thing to be made had been known that the artist Chandrasekhar returned to himself performing the servile operation with goodwill, a will directed solely to the good of the thing to be made. He was willing to make what was shown to him upon the Holy Mountain Blue (*Nilāchala*). The intellect searched out the absolute order of things as they stood in the mind of God. He was the one who, when God inspired him, took note and went setting it forth in such ways as He dictated within him.

The manual operation of the artist is called servile. In writing down, for example, the form of an astronomical composition that has already been seen phenomenally or in calculation as such, the artist is no longer free, but an imitator of what he has himself imagined or calculated. In such a servility there is no suspension of will, rather there is a loyalty to the good of the work to be done. The artist turns from intellectual to manual ope ration or vice versa at will and when the calculation has been done, he judges its truth by measuring the actual form of the artefact against the celestial image of it. Here we can perhaps separate the artist from the craftsman and fine from the applied art. We can assume that there is one kind of man that can imagine and another that cannot, or to whom we cannot afford, without doing hurt to business, to allow, to imagine and to whom we therefore permit a servile and imitative operation only. Just as the operation of the artist, who merely imitates nature as closely as possible, or as an archaist merely imitates the forms and formulae of ancient art without attempting any recreation of ideas in terms of his own constitution, is a servile operation, so is that of the astronomer, required to construct whether by hand or by machinery, replicas for which he is provided with ready-made designs, of which the ideal content is no longer understood and which are nothing but the vestiges of originally living traditions. It is precisely in this sense that

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everyone, including Chandrasekhar, is nominally, and no one is really, 'free'. Admitting the fact Chandrasekhar has quoted from the *Siddhānta Śiromani.*

> *Divyamjnānamatindriyam yaddrsibhirbrāhmya vasisthādibhih*
> *Pāramparyavasādrahasyamavanimnitam prakāsyam tatah.*
>
> S D, 20/111
>
> Astronomy is divine knowledge and cannot be acquired through senses only. It had been imparted by the Supreme Lord himself to sages like Vāsistha, who were equally divine. Therefore, it has to be learnt by tradition.

He has also admitted:

> *Yantram vinā grahagati grahanādikānam*
> *Syādvāsanā na sugama samayakramasca;*
> *Tad yantranirmitimupakramate' bhitātum*
> *Sri Chandrasekhar Krto pratibhanusarat.*
>
> S D, 20/1
>
> Without instruments, motion of planets and eclipse, etc. cannot be properly understood. Neither the motion of time can be. Hence, Sri Chandrasekhar is going to describe the process of its constructions in accordance with his wisdom.

His was an imitation, but not of a visible and transient appearance. It was of an intelligible form which need no more resemble any natural object than a mathematical equation need look like its locus in order to be 'true'.

The doctrine of scientific determinism as postulated by Laplace had been strongly resisted by many people because it infringed God's freedom to intervene in the universe, including human behaviour. Du Bois-Reymond found the existence of our free will totally perplexing and irreconcilable

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with a mechanical view of the universe and had included it in his so-called 'The seven riddles of the Universe' (*The Limits of Scientific Knowledge*, Popular Scientific Monthly, 5, 17 (1874), cf. *Impossibility*, p.50). One of the first indications of its irreconcilability had come when calculations by Lord Rayleigh and James Jeans suggested that the total energy radiated by a hot object would be infinite. The quantum hypothesis explained the observed rate of emission of radiation from hot bodies very well but its implications of determinism were not realised until 1926, when Werner Heisenberg formulated his famous uncertainty principle making perfect measurement an impossibility, because the very act of measurement would perturb the system by a relatively larger and larger amount as the dimension being probed got smaller and smaller. The application of Gödel's style of argumentation to questions of complete self-knowledge, free will, and determinism was further made by Karl Popper, by which he showed that a deterministic computing machine could not produce a prediction of its own future state which would remain valid if it was embodied within itself, because the process of embodiment would inevitably render it out of date (*British Journal for the Philosophy of Science*, 1, 117, 173, 1950). Karl Popper had used the logical equivalent of this perturbation, which is a simple consequence of the earlier arguments of Gödel and Turing, to limit the ability of a computer to understand and predict its behaviour completely: complete self-description is logically impossible. John D Barrow has said that the dilemma is not unlike that of the fictional Tristram Shandy, who found his autobiography unable to keep up with his rate of living because, 'In order to predict oneself completely, one has to predict oneself predicting oneself compl etely, and then one has to further predict oneself predicting oneself predicting one self completely. The infinite regress is clear.' (K Svozil, qf. *Impossibility*, by J D Barrow, p.233)

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John D Barrow has explained that science is difficult because there is no automatic way of finding the patterns which link together different properties of the real world. Remarkably, this suspicion can be expressed as a theorem, proved by E M Gold in 1967 (*Information and Control*, 10, 447). It shows that if we have some mechanistic intelligence, like a computer or some other form of human or artificial intelligence, there is a rule linking its input and output data which it cannot discover. That is, there is no systematic recipe for finding rules which link its input to its output. An interesting example of a finite automation, which possesses a property of complementarity, of the sort possessed by quantum mechanics, is given by K Svozil in Chapter 10 of his book *Randomness and Undecidability in Physics* (World Scientific, Singapore, 1993). This book is the most important resource for the study of the interface between mathematical undecidability and physics (*Impossibility*, p.273).

These arguments have a clear and simple message for any type of predictive and explanatory study. There are unpredictable aspects of completely deterministic phenomena and therefore Emil Du Bois-Reymond had issued his rallying cry *Ignoramus et ignorabimus* (We are ignorant and we shall remain ignorant), and Isaac Singer had said: 'We have to believe in free will. We have got no choice.' (Quoted in *The Times* (London), 'Diary' 21 June 1982)

In the early years of the twentieth century, mathematicians like David Hilbert had set about banishing paradox and undecidability from the enterprise of mathematics. But the discovery of incompleteness and undecidability led to the discovery that there must be further limitations upon our ability to get at the truths of mathematics that are decidable. The discoveries of Gödel and Turing created a wave of interest in the consequences of their work for philosophy. These were, however, by no means, the first 'impossibility'

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theorems to be proved by mathematicians. In the nineteenth century, the first proofs were given that certain geometrical constructions, like the trisecting of an angle with rules and compasses, are impossible.

Under the present circumstances, it is often argued that in some way the human mind is superior to computing machines. It is not a slave of deductive arguments. It can use intuition, guesswork, induction and all other means of non-deductive reasoning to get at the truth. For example, John Lucas in his paper entitled 'Minds, Machines and Gödel' (*Philosophy*, 36, 120/1961) says:

> A conscious being can deal with Gödelian questions in a way in which a machine cannot, because a conscious being can consider both itself and its performance and yet not be other than that which did the performance. A machine can be made to in a manner of speaking to 'consider' its performance, but it cannot take this 'into account' without thereby becoming a different machine, namely the old machine with a 'new part' added. But... a conscious mind... can reflect upon itself... and no extra part is required.

Finally such arguments have led Roger Penrose to conclude regarding the question of free will:

> I do indeed believe that there is a real issue here, rather than an imagined one, but it is profound and hard to formulate adequately. The issue of determinism in physical theory is important, but I believe that it is only a part of the story. The world might, for example, be deterministic but non-computable. Thus the future might be determined by the present in a way that is in principle non-calculable... I shall try to present arguments to show that the action of our conscious minds is indeed non-algorithmic (i.e. non-computable). Accordingly, the freewill that we believe ourselves to be capable of, would have to be intimately tied

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> in with some non-computable ingredient in the laws that govern the world in which we actually live.
>
> *The Emperor's New Mind*, p.220

This brings us to the issue of Chandrasekhar's astronomical observations in the modern context of determinism, predestination and free will and surprisingly he seems to be as logically sound as those who look at free will and determinism and learn why computers and minds cannot fully understand themselves, or predict their own futures. But in spite of incompleteness, undecidability, Chandrasekhar, like Donald Mackay, has made the strongest possible assumption about the brain's encoding of a person's thoughts and feelings: that everything they see, hear, feel, believe, etc., is completely and uniquely encoded in their physical brain state. Thus, a change of belief about some thing (that is, a change of mind) would be representable by a specific transformation from one brain state to another. He has explored some of the ways in which the mathematical end game might be played out. He has seen some of the extraordinary coincidences that must exist if our capability is to remain a match for the subtlety of nature and has located ourselves on the ladder of progress that defined our present capability to manipulate simple things, without showing any craze for gadgets. If there is an intelligence working in this world, one can expect patterns and som e kind of determinism, as our description of those patterns are what we call mathematics. Like Mackay, he has tried to show that there is a distinction between something being predictable by others and inevitable for oneself:

> *Ye proktāh sadasat phalāyajagatah srivyāsapitrādivo*
> *Rājādyā jaladāh sadadhipatayobhāgā suyogādayah*
> *Bhāvābhāvajusa nadrstavasatatattat phalānām mayā*
> *Kadācitkatayā nate' tragaditāstyaktasca siddhāntibhih.*
>
> S D, 15/61

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> Sages like Parāsara, in order to predict the future, have described Lords of the years, clouds, harvests, parts of fire, rainfall, and disease and prosperous times, but sometimes their predictions fail. Therefore, I, am not going to describe all those things.

More often than not Chandrasekhar has reminded us of his limitations as a human being but nevertheless indomitable in calculating the inevitable. According to him his calculations will hold true up to 10,000 years in future. It is not likely to have any difference in *tithi*, *naksatra*, etc., or true positions of planets (*S D*, 21/53, 54). He has even ventured to provide rules for correction which ought to be required in calculations after 10,000 years (*S D*, 21/55–70). When scientists redefine the task of science to be the discovery of laws that will enable us to predict events up to the limits set by the uncertainty principle (*A Brief History of Time*, p.183) and, to reformulate mechanics into a new theory called quantum mechanics based on the uncertainty principle; Heisenberg, Erwin Schrodinger and Paul Dirac in the 1920s thought it better to employ the principle of economy known as Occam's razor and cut out all the features of the theory that cannot be observed, Chandrasekhar's principle of economy commands respect. He has said:

> *Sarvāscaryamahāmbudherbhagavatah sthulevibhau dhāmani*
> *Kridāndā nnganāh sphurantikatidhā no betti vedhā api*
> *Tasmādveda purāna varnita jaganmānā dikam no mrsā*
> *Kimtvasmadvasaterbhuvo' ntika jusāmesāsthitirjyotisam.*
>
> S D, 19/123

> God is the ocean of wonders, there are innumerable worlds within his great body. Their number cannot be exactly known to Brahmā even. Still the measurements of the world as given in the Vedas and Epics or Puranas may not be untrue. In spite of that I must limit myself only to this visible part of the universe.

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Evamanye suksmarupāh santyasankhyā nabhascarāh
Tathaivopagrahāh santi grahabestanakārinah
Te suksma yantralaksatvat purvagatyā grahaiti
Unnitāpi dhātrā dyairanuktatvādi hojjhitah.

S D, 5/79–8

There are numerous small planets in the sky. Around planets satellites move in circular paths. Motion of these bodies can be seen only through instruments like telescope. As they have not been mentioned in ancient *siddhantas*, may be ignored.

Donald Mackay has suggested that a deterministic model of brain action (like that of Samanta Chandrasekhar, say) would not render untenable the belief that individuals enjoy freedom of choice. He has applied this to the question of divine foreknowledge. According to him:

Even God's sovereignty over every twist and turn of our drama does not contradict our belief that we are free, in the sense that no determining specification already exists which, if only we knew it, we should be correct to believe and in error to disbelieve. Whether we liked it or not; and 'that' divine foreknowledge is not something that we would be correct to believe if only we knew it, since for us (unlike God) this would involve a contradiction.

Cf. *Impossibility*, p.235

Accordingly as Sri Aurobindo argues: Mackay's notion of free will is:

Apt to be tainted with the excessive individualism of the human ego and to assume the figure of an independent will acting on its own isolated account in a complete liberty without any determination other than its own choice and single unrelated movement. This idea ignores the fact that our natural being is a part of cosmic nature and our spiritual being exists only by the supreme Transcendence.

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> Our total being can rise out of subjection to fact of present Nature only by an identification with a greater truth and a greater Nature. The will of the individual, even when completely free, could not act in an isolated independence, because the individual being and nature are included in the universal Being and Nature and dependent on the all-overruling Transcendence. There could indeed be in the ascent a dual line. On one line the being could feel and behave as an independent self-existence uniting itself with its own impersonal Reality; it could do so self-conceive; act with a great force, but either this action would be still within an enlarged frame of its past and present self-formation of power of Nature or else it would be the cosmic or supreme force that acted in it and there would be no personal initiation of action, no sense therefore of individual free will but only of an impersonal cosmic or supreme Will or Energy at its work. On the other line the being would feel itself a spiritual instrument and so act as a power of the Supreme Being, limited in its workings only by the potencies of the superstructure, which are without bounds or any restriction except its own Truth and self-law, and by the Will in her. But in either case there would be, as the condition of a freedom from the control of a mechanical action of Nature-forces, a submission to a greater conscious Power or an acquiescent unity of the individual being with its intention and movement in his own and in the World's existence.
>
> *The Life Divine*, p.915–926

Sri Aurobindo's above argument clearly justifies the condition under which Chandrasekhar had exercised his free will so as to say: 'It is He, the beloved husband of the daughter of Ocean, who has thrown my intellect out of the way of incantation, into an emporium of mathematics. May He, the merciful, provide me shelter so that I do not lose my way in this hardship.' (*S D*, 15/71)

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Chapter XI
THE MIRROR AND THE LAMP

Itimuditasudhire' suddhasiddhāntapurve
Nayana bisaya siddhabyomage darpane' smin.

S D, 15/73

Thus ends the first part of the mirror of astronomy, having fifteen chapters of reflected rays in three sections, through which the heavenly bodies could be envisioned.

Siddhānta pramukhe prakasanavala spastādhikāradvayo
Yuktam darpanake' tra golaganita khyātyatyattarārdhamgatam.

S D, 24/151

Thus ends the second part of the mirror of astronomy to which nine chapters of reflected rays in two clear sections have been added.

The distinction between the looking-glass image and the veritable spiritual essence of man has been sharply drawn in the *Chandogyopanisad* (VIII 8.5) where the question has been posed of the nature of the spiritual essence, or very self (*atman*) in a dialogue between Brahmā, the Progenitor, Indra, the Lord of the heaven and Virocana, the Lord of the underworld. The Progenitor has asked the latter two to adorn themselves as best they could and to consider their reflection in a bowl of water. 'What did you see?' 'We saw ourselves just as we were with all our adornments,' they replied. 'That is the spiritual essence, the immortal, the God,' he told them meaning that what they saw was a form in the image and likeness of the Divine. The same image

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recurs in the *Brhadāranyakopanisad* (11.2.8–9). The ignorant doctor Gārgya had been worshiping the person reflected in the water or in a mirror, i.e. his own person and had been corrected by the Gnostic Ajatasatru who said that he had been worshipping the Person in a likeness and as the Refulgent, who was the archetype of the image, not as seen in physical waters or mirrors, but in the heart. Indra and Virocana, however, understood that the outward aspec t and the spiritual essence were one and the same thing and they went away satisfied with this atheistic conclusion. The Progenitor watched them as they went and remarked: 'They have gone away without understanding, without having known the very self. Whoever has such understanding as theirs, whether Angel or Demon, must perish.' Indra, however, was not finally satisfied and returned again and again for further instruction and finally learnt that this body, mortal though, was the standing ground of the immortal spiritual essence, the veritable knowing subject.

Likewise, it was the whole burden of the astronomical literature of India to identify the knower of the field and the field itself. It was a search for getting at the appearance of the Supreme Being, the interior image of the very universe invisible to the physical eye but accessible to the eye of contemplation. Chandrasekhar has said:

Vimbāntarvarttinah pumsah samkrāntisamayonrbhih
Truteh, sahasrabhāga tvadavagantum na sakyate.

S D, 22/58

The movement of the Person in the centre of the refulgent at the time of *samkrānti* is too swift to be perceptible for human eyes. His crossing over to another *rāsi* may be well within one-thousandth part of a *truti* i.e., 1/33750000 second.

Hrt prānendriya rodha sodhita sama krodha smaradidvisah
Pancaklesamucona yat ksanamapi drastumksamā yoginah

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Tad yahsvam paramapadam sva carana premādhva panthairjanaih
Suprāpam bidadhātinah sa bhagavān byād bhavabapyā padah.

S D, 21/251

Ascetics, who win over their enemies like illusion, anger, and desire, etc., by controlling their mind and breath and become free from the five sufferings like knowledge, consciousness, obsession, enmity, and attention; even fail to have a glance of the Supreme Being even for a moment. But he is pleased to appear before his devotees rather more casually...

According to the guiding principle of Sam anta Chandrasekhar's pursuit of knowledge, it may be questioned whether his knowledge of God was also based upon the same dictum: 'Experience is its own justification' (*Pratyaksanubhavam na lumphati vaco yuktiryatastanmaya*, *S D*, 6/2). In anticipation of such a question he has gone on to explain, by quoting *Yoga Vāsistha Rāmāyana* (*S D*, 22/9–11) that God's existence can of course be directly experienced, even be perceived, as a form of holding sword and noose, being adorned with armour and earrings, having six mouths and twelve hands (six seasons and twelve months), etc. It obviously resembles the renderings in the *Brhat Parāsara Smrti* and the *Tantrasāra* where the sun god has been claimed to be envisioned as:

Keyuravan makarakundalavan
kiritiharihiranmayabapur dhrtasamkhacakra.

Chandogyopanisad says:

Atha ya eso' ntaradityc hiranmayah puruso drsyate'.

1.6.6.7

Within the solar orb the golden-hued god is seen.

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So also the *Yājnavalkya Smrti* says: '*Dhyaneno purusoyasat drsyah sa suryamandale.*' A number of evidences can thus be cited from ancient Indian theology from which it is construed that God, if there is a God, can only be seen through the sun. Because in Indian conception God is nothing but light. The Vedic civilisation began with the hymn to God of light thousands of year ago. The seers gave voice to the Indian mind and their imagination was illumined with the gift, of God, the Real God, *Brahmā suryasamam jyotih* (Yajur Veda, 23.48), *Visva mābhasi rocanam* (R V 1.50.4). The Rg Veda emerges out of the primordial dawn with the cacophony of hymns lifted from the soul of man to an all-creative truth and an all-illuminating light. Truth and light are synonymous in the thought of the Vedic seers even as are their opposites, darkness and ignorance. The battle of the Vedic gods and demons is an unending conflict between day and night for the possession of the three worlds. Thus the first and foremost aspect of Surya is that he is the Supreme Light of the truth attained by the human being after his liberation from the ignorance. The Vedic way of putting the idea is expressed in the hymn: 'Beholding a higher light, beyond this darkness we have followed it and reached the highest ligh t of all, Surya divine, in the divine Being (R V 1.50.10). In the same light the ancient astronomers also assume the light of Surya as the form, the body of that divine vision. He is described as the pure and visioned force of the truth which shines out in his rising like the *Hiranyagarbha* i.e., the golden egg. He is the great godhead who is the vision of Mitra and Varuna, he is the large and invincible eye of that wideness and that harmony. He is that large truth-vision who sees all that is in the gods and all that is in men, the far-seeing eye of knowledge born of the gods' (R V X.37.1). It is by this divine light that the mirror of astronomy is illumined.

Besides borrowing the lines of the *Surya Siddhānta* (*S D*,

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18/3–22) in which this Vedic perception has been incorporated, Samanta Chandrasekhar has described the embodiment of God, throughout his book as the Refulgent:

Yascaksurgrahanātimo' pi gagane grhnan grahānām ganam
Bhugolaparigacchati grahapatih sarvagrimomadhyamah
Lokāloka visokatābanikrte spastastrayo murtimān
Yascaksurjagatātmano bhagavatastasmai savitre namah.

S D, 16/2

He has also equated him with Lord Jagannāth, the Lord of the universe (*S D*, 2/25, 23/28) and in order to remove the apparent dichotomy he has said: 'The sun, according to Horāskandha, is the soul of God's manifestation as Time and as such is the Lord of this World. There is virtually no such paradox between the astronomical sun and the sun God of the theology' (*S D*, 22/15–17). But at the same time he has reminded us of the twin aspects of the sun:

Atodve rupamarkasya Brahmāndāntah pratiyate
Tatrādyasyātmabhughasra kartrtvam sambhavatyatah
Dvitiyasyā surāmartya pitrmartya dinesatā
Visva devātmakatvācca suryādinam dvirupatā
Taijasam bhāsvato bimbamudbhutam sparsa rupakam
Pancabhoutikamapyetadbhāsvaratvāt pradipavat.

S D, 18/26–28

Hence the sun has two forms. The first one is the cause of the creation of Brahmā and the second one is the effect of Brahmā's creation through which the creation started. The first sun is the soul of the Creator, the Lord of the universe: the second sun is the Lord of the gods, demons, and human beings. The first sun who is in the form of a god soul is not easily visible. But the second sun who is in the form of a sphere composed of material elements burns like a 'cosmic lamp' and its form can be perceived through touch as well as vision.

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Both mirror and the lamp are meaningful only to persons who have a perfect sight. Therefore, Chandrasekhar has made it an offer to them, only to them: '*Sidd hantadarpane' smin salocananam pratyarpane nipunah.*' (*S D*, 1/13)

As a student, Newton was fascinated by the light and transfixed by the sun. He took to the dangerous practice of staring at the sun's image in a looking glass (Cf. *Cosmos*, p.55). Chandrasekhar was no less fascinated. He has stated: 'In the Kali era of 4975 (AD 1874) a solar eclipse occurred due to Venus (*Sukra*) when the sun was in the twenty -five parts of the Scorpion in the zodiac (i.e. in Nov–Dec). The image (*bimba*) of Venus was seen to be 1/32 of the solar image' (*S D*, 11/110). 'By observing through instruments I have measured the diameter (angular) of the mean sun and found that the amount as has been stated in the *Brahmavidya Upanisad* and *Atharva Veda* (72,000 *yojanas*) is correct' (*S D*, 19/48–52). These instances do not tell only upon his interest to measure the distance or size of the sun but also on his concern to understand the meaning of *Pranava* or *Aum* (*Pranavārtha nirupane*). The significance of stating the angular diameter of the sun in the context of understanding the meaning of 'Aum' is however, a mystery. As Arthur Zajonc has concluded:

> In my own professional life, I first sought to understand light of means by laboratory research in quantum optics. In laser experiments performed at institutes in Boulder, Amherst, Paris, Hanover, and Munich, I studied light and the way it touches matter. The more I learned of the quantum theory of light, theoretically and experimentally, the more wonderful light seemed. Even armed with such sophisticated theories, I have no sense of closure regarding our knowledge of light. Far from it, light remains as fundamentally mysterious as ever.
>
> *Catching the Light*, p.7

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'Astronomy' is not the exact synonym of the Indian word 'Jyotisam' which in fact means the knowledge of light, the celestial light of course. Since the Vedic times, as it were, the seers have endeavoured to understand what light is, if not by means of laboratory research, then surely by means of a sacrificial rituality. Right from the beginning the y have realised that divine light is not an inert substance, not merely a prerequisite for existence of living beings, but is itself alive. Like any other living entity it also corresponds to propitiation. *Jyotisa*, in ancient times, was a part of Tantra or esoteric exercise, and was the most effective way for having communion with God. The way to enlightenment became obsolete and redundant due to growing influence of the materialistic approach of the Western science in India. Any materialistic analysis of light, nay God, must lead us to despair as in 1951 Einstein has had to chime in style: 'All the fifty years of conscious brooding have brought me no closer to the answer to the question, "What are light quanta?" Of course today every rascal thinks he knows the answer, but he is deluding himself.' (Quoted in Emil Wolf, *Einstein's Researches on the Nature of Light*, *Optics News*, vol. 5 No. 1, 1979, pp.24–39)

But Chandrasekhar was too wise and devoted to be deluded, as light, for him, could not be anything less than God Incarnate:

Gangeyadyutibhangadangalatayā srirādhayā lingitam
Bidyutsāngighanaghanapaghananankpremāmrtaikāsrayam
Satsambitsukhamaksara ksaraparam purnāti purnottamam
Srikrsnākhyamupāsmahe suruciram vedāntavedyam mahah.

S D, 1/2

I worship the refulgence of Lord Krsna, the Dark One, whose radiant glow can only be realised through the Vedanta. The illumination is absolute, illimitable and unique. It is neither material substance nor living

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> organism. It is the rarest combination of Truth, Consciousness, and Bliss. It sustains the nectar of love. It is always in embrace with the blazing beauty of Sri Radha as a dark cloud is embraced by the lightening.

What does this imagery suggest? It suggests that light is not only mysterious but also dark and invisible when left entirely to itself. Nowadays, it has already been confirmed by space walkers like Apollo astronaut Rusty Schweickart that the sun's light in space, although present everywhere, falls on nothing and so nothing but darkness is visible. However, when it embraces a material body, the object becomes visible. Radha etymologically means the seed of light. The sun visibly appears to be the entwined incarnation of brightness and blackness, i.e. Radha–Krsna, the supersubstantial entanglement of subatomic u niverse. Mystery and manifestation arise from the same source. Surya, according to the Vedic symbol, releases into the wideness, the mystic cow of light. Hence, he is the Supreme Cowherd Krsna or Govinda.

The conquest of the sun is a frequent subject of allusion in the hymns of the Rg Veda. The finding and recovery of the mystic cows i.e., the symbolic hidden or lost rays of the sun is usually described as the work of Indra often with the aid of the Angirasa *Rsis*, and by the instrumentality of the *mantra* and the sacrifice, of Agni and Soma, so also the finding and recovery of the sun is attributed to the same agencies. The hymn of Bharadwaja to Indra (VI.72.1) says: 'Ye found the Sun, Ye found Swar, ye slew all darkness and limitation.' The hymn of Vamadeva to Indra (IV.16.4) which celebrates this achievement of Indra and the Angirasas, says: 'When by the hymns of illumination (*arkaih*) Svar was found, entirely visible, when they (the Angirasas) made to shine the great light out of the night, he (Indra) made the darkness ill-

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assured (i.e., loosened their firm hold) so that men might have vision.'

In all these allusions we see a theory of correspondence between the divine and the mundane. Surya is found by the Angirasas through the powers of their hymns and instrumentalism. *Svar* (*Svarloka*) is found and made visible by them as a *great region of divine light* where the godhead of light could be seen. The Vedic hymns are obviously not simple morning prayers of the introvert, the disillusioned ascetics, nor the cows are wealth of earthly herd. But as is stated by *Purucchepa Daivodasi* (1.130.3): 'Those are the treasures of heaven hidden in the secret cavern like the young of the Bird, within the infinite rock, like a pen of the cows.'

Jyotisam is the eye of this Vedic knowledge, the instrumentality through which the invisible godhead can be made visible. In spite of the watershed of empiricism as envisaged by the Western science making headway into Indian subcontinent, the mumpsimus like Samanta Chandrasekhar could marvel that the Vedic culture reveals as much about itself, about the light of its people's minds, as about nature's light. The Vedic hymns to the night opens with a sublime antithesis '*hvayami ratrim jagato nivesanim hvayamidevam savitaramutaye*' (1.35.1). The Vedic people understood the efficacy of night as efficiently as of the sun. In the midst of outer darkness, an inner light illumines an imaginal landscape of knowledge, unspeakable and mysterious like the night sky. The Vedic seer sings the universe he sees into the hearts of his listeners so that they too might contemplate. As the sun is the Lord of the day, likewise the moon is of the night and they both play the most important part, most intricate part in the Vedic astronomy (*surya candramasou dhata yathapurvamakalpayat*). For understanding the nature of light both of them are indispensable, hence their importance in the *siddhantas*. Two eyes look down on

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the Vedic civilisation, the two eyes of *Purusa*, the sun and the moon. The gaze of the sun is the light of the day. Like the Vedic sun god, in Egypt the Sun god *Ra* (Skt, Ravi) performs the day and night when he opens his eyes, there is light. When his eyes close, darkness falls. The story of the 'lost eye' of Horus (Skt. Hari) in Egyptian mythology perfectly resembles the Vedic story of the *Saramā* (Egyptian Shu) and the lost cows or the lost sun and their recovery. The mythologies of all the ancient civilisations are found to be identical in respect of the sun. But nowhere it is so original and systematic as in the Vedic civilisation.

However, we are more concerned with the seers like the *Atris* and the *Angirasas* who felt for the first time, in the Vedic civilisation, the force of their own vision, the light of their own eye and developed a theory of predicting the phenomena of light which in the long run gave rise to *Vedanga Jyotiṣa*, and the Upanisadic theory of vision. Samanta Chandrasekhar's was the up-to-date version of that (*S D*, 1/15). The Upanisad had taught him to direct his mind towards the divine presence in the sun: 'There the sun shines not, nor the moon and stars, nor this lightening; of what account is this fire? He alone shining, everything shines after, through his lustre all this shines' (*Kathopanisad*, V. 15/*Mundakopanisad II*. 2.10/*Śvetāśvettaropanisad*, VI. 14) and:

> Taking as a bow the great weapon presented in the Upanisads, fix on it an arrow that has been sharpened by meditation. Then stretching the bow fully, with a mind wholly absorbed in its thought (i.e. of Brahmā), do thou hit the target which is the imperishable Reality. The AUM is the bow, the mind is the arrow, Brahmā is the target. It is to be hit with concentration and one should become unified with the target just like the arrow.
>
> *Mundakopanisad II*, 2, 3–4

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The *Aksi Upanisad* has termed it as *Caksusmati Vidyā* or 'the knowledge of eyeing' which had been obtained by *Samkrti* – (*Athā ha Samkrtirbhagavānādityalokam jagāma. Tamādityam natvā cāksusmatividyāya tamastuvat, AUM namo bhagavate Sri Suryāksitejase namah, AUM Khecarāya namah AUM mahāsenāya namah, AUM tamase namah, AUM rajase namah, AUM sattvāya namah... Aksi* U. II)

Chandrasekhar has gratefully acknowledged his indebtedness to the *Brahmā Upanisad* not for its limited usefulness in scaling the angular diameter of the sun, but also for understanding the meaning of *Pranava* which is so important in identifying oneself with the God of Light.

Bertrand Russell, in his brilliant essay *Physics and Experience* (*Human Knowledge*, Ch. VI, Part III, pp.211–226) has put forth a question which intervenes in a very apparently awkward way at this point of our inquiry as to whether experience can be its own justification (*Sacetasamanubhavah pramanam tatra kevalam*, *S D*, III. 4). The question is: 'Assuming physics to be broadly speaking true, can we know it to be true, and if the answer is to be in the affirmative, does this involve knowledge of other truths besides those of physics?'

Now a percept – say seeing the appearance of God – has a series of antecedents which according to our modern conception of vision travel in space–time from the physical source of the appearance through the air to the eye and brain. The experience which we call 'seeing the appearance' or the Upanisad calls 'Thou art there' (*Tat Tvam Asi*) is as nearly as can be determined simultaneous with the cerebral term of the physical causal chain. If the appearance is of the kind to call forth a bodily movement, the movement begins almost immediately after 'seeing the movement'. If we are going to fit 'seeing the appearance' into a physical causal chain, we must therefore connect it with the same region of

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space–time as that of the accompanying cerebral events. And this applies also to the appearance, as something perceived. The only region of space–time with which this appearance has any direct connection is the present state of the seer's brain; the connection with the physical source of the appearance is indirect. Whether we consider the percept or the simultaneous state of the brain, the causal location of either is intermediate between occurrences in afferent nerves constituting the stimulus; and occurrences in efferent nerves constituting the reaction. Then where do we locate our God?

'The astronomer's Sun,' according to Russell, 'is inferred, it is not hot or bright, and it existed eight minutes before what is called "seeing" it. If I see the sun and it makes me blink, what I see is not 93,000,000 miles and eight minutes away, but is causally (and therefore spatio-temporally) intermediate between the light waves striking the eye and the consequent blinking.' From this he has concluded that the relation of a percept to the physical object which is supposed to be perceived is vague, approximate, and somewhat indefinite. But Russell's 'deduction is not so appropriate to "light" itself as it is to the "objects" reflected by light, in this context. In case of light itself as an object of perception his view that there is one, and only one, region of space–time with which our seeing is causally bound up and that is our brain at the time of the seeing; strangely conform to the Upanisadic view' *manasāhyeva pasyati*. It is not the eye but mind that sees.

The eye and the sun displayed to Plato a deep harmony like that of the Vedic seers. Though ancient, it had been appreciated by the German poet Goethe who, in the introduction to his own *Theory of Colour* (1810), had preferred to say:

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Were the eye not of the sun,
How could we behold the light?
If God's might and ours were not as one,
How could His work enchant our sight?

By the sixteenth century, however, a profound shift seemed to be nearly maturing. Natural philosophers such as Kepler, and to a greater extent Galileo, were less concerned with the soul's translation of external stimulation into meaningful perception, and more preoccupied with the physics of the eye viewed as an inanimate, physical instrument. Gradually, sight became a question of mechanics rather than a species of soul-spiritual activity. A device known as the *camera obscura* which literally means 'darkened chamber' affected the scientific imagination. In the first years of the seventeenth century the mathematician and astronomer Johannes Kepler developed a complete geometrical explanation for the *camera obscura* and went on to give a detailed and successful explanation of the optics of the eye and vision in terms of it. Yet Kepler, like so many scientists before him, was deeply disturbed by one fact: the image on the screen of a *camera obscura* is inverted! How can the image on the retina be upside down when we see the world right side up?

Newton's conception of light began with his natural inclination towards a mathematical and mechanical philosophy of nature. He opened his *Opticks* with a definition: 'By Rays of light I understand its least parts, and those as well successive in the same lines, as contemporary in several lines' (*Opticks*, 4th edition, New York: Dover, 1952, p.1) which was based on a fundamental unit or conceptual atom of light whose laws of motion were none other than the laws Newton had already discovered as those governing the motions of planets. Light was reduced to matter moving in obedience to the laws Newton unearthed.

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Thus a 'twilight of Gods' set in the minds of those scientists who were in the oft-dangerous vanguard of research. Later on, it was detected that the corpuscular view of light could not explain a phenomenon like wave for which the wave theory of light was proposed by Leonard Euler in 1746 in his *New Theory of Light and Colour*. Still even Euler and his vibrational theory could not explain all of light's many manifestations, and primary among them were the phenomena of diffraction. Then 'the greatest alteration in the axiomatic basis is of physics – in our conception of the structure of reality – since the foundation of theoretical physics by Newton originated in the researches of Faraday and Maxwell on electromagnetic phenomena' (Albert Einstein, *Catching the Light*, p.145) which altered our conception of space and light.

Thus it may be seen, the nineteenth century physics community was confident that through the mechanics of Newton, the electromagnetic theory of Maxwell, and the pristine science of thermodynamics, every phenomenon could be accounted for. But they failed. In 1899, physics even could not account for the colours of candlelight! (*Catching the Light*, p.231). The discovery of 'invi sible forms of light' broadened enormously the conception of light held by physics. Nowadays it is conceived of as running the entire gamut from radio waves to gamma rays to black -body radiation. Realising the predicament Sir J J Thompson, the discoverer of the electron had remarked: 'The study of light has resulted in achievements of insight, imagination and ingenuity unsurpassed in any field of mental activity; it illustrates too, better than any other branch of physics, the vicissitudes of theories.' (Cf. *Catching the Light*, 1925, p.231)

Hopefully we might look at the quantum theory for consolation because if light waves are now problematic due to the uncertainty of the existence of ethereal medium, it allows us to resort to a corpuscular view. But while

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quantum theory speaks of a particle-like nature of light, the photon remains massless and possesses, in addition, its own set of unusual properties. It embroils our observation even more deeply through Heisenberg's principle of uncertainty. Quantum theory does not help us to get out of the riddles. Light is not a material substance, at least not in the form of a massive particle, nor even in the form of undulations through a material medium. If we conceive of the universe as matter or its movement, light is the exception that deludes us.

Perhaps even in the West, the bell is still jingling with the citation: 'This is the message we have heard from him and proclaim to you, that God is light and in him is no darkness at all... if we walk in the light, as he is the light, we have fellowship with one another.' (Bible, John 1: 67–79)

Yasascaturvargaphalapradam srutam
Pavitrametat pathaniyameva tat
Aharpatih prāha rahasyamityatah
Pradeyametat pravanāya sadhave.

S D, 1/19

Srnusvaikamanāstatvam guhyamadhyātma sangitam
Pravaksāmyeva bhaktānām nadeyam vidyatemama.

S D, 18/3

> This knowledge has been imparted by the sun god himself with the command that it should be kept secret. It should be handed over to pious and devoted men only. Because God has nothing which he can hold on to himself before His devotee.

In considering Chandrasekhar's system of astronomy, it must not be forgotten that the problem of the universe seemed much simpler in his days, than it does in our own. Men had not then recognised that knowledge is a galaxy

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whose margin fades for ever and for ever as we move. Rather they believed that truth was something definite, which might be grasped by, the aid of a resolute mind, diligence, and an appropriate method. Hence, a tone of confidence breathed through their inquiries. But the products of human thought are often valuable in ways undreamt of by those who fashioned them, and long after their original use has become redundant. A system, apparently inadequate, may yet enshrine ideas which the world is the richer for possessing. As no system is entirely true, so also no system is entirely original. Each must in some measure be the recombination of elements supplied by its predecessors.

The genealogy of Indian astronomy goes back to the enigmatic Maya with whom the sun god had talked face to face. All subsequent treatises on astronomy, including Chandrasekhar's *Siddhānta Darpana* acknowledge that it was a revelation.

Revelation or prophecy, as Benedict de Spinoza has defined, 'is sure knowledge revealed by God to man. A prophet is one who interprets the revelations of God to those who are unable to attain the sure knowledge of the matters revealed, and therefore can only apprehend them by simple faith.' (*The Tractatus Theologico-Politicus*, tr. R H M Elwes, George Bell & Sons, vol. 1, Dover Publications Inc., N Y, Ch. 1, Of Prophecy, p.1)

Spinoza has further explained that prophecy really includes ordinary knowledge, for the knowledge which we acquire by our natural faculties depends on our knowledge of God and His eternal laws; but ordinary knowledge is common to all men as men, and rests on foundations which all share, whereas the multitude always strains after rarities and exceptions, and thinks little of the gifts of nature; so that, when prophecy is talked of, ordinary knowledge is not supposed to be included. Nevertheless, it has as much right

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as any other to be called divine, for God's laws dictate it to us; nor does it suffer from that to which we give the pre-eminence, except in so far as the latter transcends its limits and cannot be accounted for by natural laws taken in themselves. Our mind subjectively contains in itself and partakes of the nature of God, and solely from this cause is enabled to form notions explaining natural phenomena. All that we clearly and distinctly understand is dictated to us by the idea and nature of God; not indeed through words, but in a way far more excellent and agreeing perfectly with t he nature of the mind.

That Chandrasekhar had enjoyed unique intellectual certainty would doubtless attest that it was He who was dictating him as similarly as He had dictated Maya. And the fact is far beyond blasphemy. 'All that is true, by whomsoever it has been said, is from the Holy Ghost.' (St Thomas Aquinas, *Summa Theologica*, 1–11.109.1 and 1)

Even the conventional speed of light, which is supposed to be 299,792,458 metres per second, does not pose a threat to the unlimited power of light god. Since Michelson's experiment (1931), even more precise methods have been devised to measure the speed of light. The last used highly stabilised lasers and special techniques for measuring ultra-high optical frequencies. Measurement finally became so exact that the main inaccuracy in them was due to uncertainties in the world's standard unit of length : the metre. In 1983, it was therefore decided to end the long history of the measurement of the speed of light forever. Instead of defining a unit of length, as had always been the case before, the speed of light would be defined! Its value was taken to be the then current best-measured value of 299,792,458 metres per second. From 1983 on, the speed of light was no longer a quantity that could be measured; rather it was defined as a matter of pure convention to be

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the above value. While experimentalists resolved one issue, relativity theory opened another, taking the great but finite speed of light, and declared it unique. Even in 1905 Einstein had stated: 'We shall find in what follows that the velocity of light in our theory plays the role, physically, of an infinitely great velocity.' (*Catching the Light*, p.265–266)

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Chapter XII

CONCLUSION: THE MIDNIGHT AND THE SUNRISE AT LANKA

Millions and millions years ago, a slender crescent moon measuring one *kalā* once appeared in the sky at Lanka. It was midnight of Brahmā and the planets started moving. Counting of days began. It was named as the Sunday. Later on the full moon appeared in the zodiacal sign of *Chitrā*. The month was known to be *Chaitra*. Another day began in the life cycle of Brahmā. (*S D*, 1/47–52)

'The existence of a poetics of science,' according to Melandri, 'is undeniable... barring poetics from science is the same as barring use of the hypothesis.' (*La Linea e il Circolo*, quoted in the Introduction to *The Poetic Structure of the World: Copernicus and Kepler* by Fernand Hallyn, tr. Donald M Leslie, Zone Books, N Y, 1990)

Karl Popper defines hypotheses as: 'free creations of our own minds, the result of an almost poetic intuition, of an attempt to understand intuitively the laws of nature' (*Conjectures and Refutations*, R & Kegan Pauls, London, 1972, p.192). So has Paul Ricoeur drawn our attention to the analogy between the role of the 'mythos' in Aristotle's *Poetics* and the role of 'heuristic fiction' in scientific research (*The Poetic Structure of the World*, p.13). In ancient Indian astronomy including Chandrasekhar's, the given imaginary moment at which, celestial sphere is supposed to have started moving is one of such unavoidable hypotheses. Of all scientific events this acataleptic moment of beginning that Charles Peirce would call 'abduction', encompassing all

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the operations by which theories and conceptions are given birth in astronomy is the most problematic for both the epistemologist and the historian of science. Indian astronomers had inevitably invented a basic metaphor for the purpose. But the basic metaphor, i.e. 'midnight or sunrise at Lanka' which is the most important ingredient of the geocentric proposition has hitherto been misunderstood and misrepresented. Actually, it should be located as a fixed point on earth at which a ray of light from the sun must fall throughout the year irrespective of sun's northern or southern course along the ecliptic. Hypothetical though, it is not that unrealistic. Had the earth been a transparent globe, its centre would have been the desired point. In 'thought-experiment' (Gedanken experiment as Einstein could perform purely in thought) it is not impossible to find out a stable terrestrial point with respect to the sun and this proves the stability of the earth.

To speak of Chandrasekhar's poetics is justified as it lends some specificity, over and above existing approaches, to the study of their projects, their choices, and the processes involved. The choice of certain common place is inherent in his choice of projects and procedures such as mimesis (schemas of representation), semiosis (schemas of meaning), telos (valuation schemas), etc. The most profound poetic change from the foreign heliocentrism to native geocentrism concerns astronomy's telos, its ironic or anagogic schemas for appraising value. Likewise Chandrasekhar's text is impregnated with a cosmogonic semiosis. It represents the universe as a collection of signs that concretise ideal transcendences. Examining the poetic presuppositions of Bhaskar-II, Chandrasekhar makes explicit and enlarges the scope of some new potentialities. The theme of the Lord of the universe leads to the allegory of Protagonist as a figure for the Creator. Since the symbol of the beloved occupies the centre, earth is conceived as the

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embodiment of the beloved creatrix, that maintains the planets including the sun in their orbits. Geome ters' astropoetics finally give rise to an immense hyper-codification of the world.

The charm of astronomy, with many, does not reside in wonders revealed to us by the science, but in the strange beliefs with which in old times it has been associated, the religious liturgics to which it has given birth. Faith in stellar influences is so widespread that astronomical terminology comes to form a part of our ordinary language.

Apart from all these allusions, of course it will be noticed that the spinal chord of this body of literature is truth and no impulse other than intuitive mathematics drives the geometers for its attainment. Chandrasekhar was not a paradoxist, in the sense Richard A Proctor has used the term (*Myths and Marvels of Astronomy*, Chatto and Wind us, Piccadilly, London, 1878). For instance, Richard has said:

> There is one special use to which the study of paradox literature may be applied, which – so far as I know – has not hitherto been much attended to. It may be questioned whether half the strange notions into which paradoxists fall must not be ascribed to the vagueness of too many of our scientific treatises. A half-understood explanation, or a carelessly worded account of some natural phenomenon, leads the paradoxist, whose nature is compounded of conceit and simplicity, to originate a theory of his own on the subject. Once such a theory has been devised, it takes complete possession of the paradoxist's mind. All the facts of which he thenceforward hears which bear in the least on his favourite craze, appear to give evidence in its favour, even though in reality they are most obviously opposed to it. He learns to look upon himself as an unappreciated Newton, and to see the bitterest malevolence in those who venture to question his preposterous notions.
>
> p.268

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Chandrasekhar's advocacy of geocentrism does not fall under such paradoxistic attitude because its provability has always been open to discussion in our 'lived' world.

To prove the immobility of earth, it would seem, the great pyramid was erected in Egypt. By supernatural means, the architects were instructed to place the pyramid in latitude 30° north, to select for its figure that of a square pyramid, carefully oriented, to employ for their unit of length the sacred cubit corresponding to the 20,000,000th part of the earth's polar axis, and to make the side of the square base equal to just so many of these sacred cubits as there are days and parts of a day in a year. They were further, by supernatural help, enabled to square the circle, and symbolised their victory over this problem by making the pyramid's height bear to the perimeter of the base the ratio which the radius of a circle bears to the circumference. Moreover, the great precessional period, in which the earth's axis gyrates like that of some mighty top around the perpendicular to the ecliptic, was communicated to the builders with a degree of accuracy far exceeding that of the best modern determinations, and they were instructed to symbolise that relation in the dimensions of the pyramid's base. A value of the sun's distance more accurate by far than modern astronomers have obtained (ever since the recent transit) was imparted to them and they embodied that dimension in the height of the pyramid. (*Myths and Marvels of Astronomy*, pp.52–53)

Similar attempt, it may be recalled, was made in constructing the Sun Temple at Konark, in Orissa. Do we hope for another finer attempt so that through the Sun Temple, Chandrasekhar's soul will be resurrected?

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A STUDY OF THE

siddhãnta darpana

Dr P K Patnaik

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ISBN: 81 7662 329 6
9 788176 63296
Rs 250

Minerva Press (India) Pvt. Ltd.
London New Delhi Mumbai

Design : Ravi Sharma

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